ASIS

TECHNICAL MEMORANDUM ASRCE TM-62-24
SUPPLEMENT I

This report is not to be used in whole or in part for advertising or sales promotion purposes.

AD413858

AN INDEX TO NON METALLICS R&D PROGRAMS OF TEN AEROSPACE COMPANIES

PREPARED BY

MATERIALS APPLICATIONS DIVISION
AIR FORCE MATERIALS LABORATORY
DEPUTY FOR TECHNOLOGY

9 May 1963

Task 738103

Aeronautical Systems Division
Air Force Systems Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government Procurement Operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

DUE DATE	DATE RETURNED	DUE DATE	DATE RETURNED

Copies of ASD Technical Memorandums should not be returned to the Aeronautical Systems Division unless return is required by Security Considerations, contractual obligations or notice of a specific document.

Aeronautical Systems Division
Air Force Systems Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

Technical Memorandum
Supplement I
ASRCE TM-62-24

Materials Applications Division
Air Force Materials Laboratory
Deputy for Technology

AN INDEX TO NON METALLICS R&D PROGRAMS OF
TEN AEROSPACE COMPANIES

I. PURPOSE:

To provide an aid for retrieving information about R&D programs concerning non-metallics being conducted by ten aerospace companies.

II. FACTUAL DATA

1. This index (Appendix I) is a follow-on to the index presented in ASRCE TM-62-24, and it covers 167 annotated abstracts describing non-metallics R&D programs being conducted by ten aerospace companies. The abstracts (Appendix II) were assigned index numbers ranging from 236 to 402. All of the programs described are recent and many of them are still in progress. Over 300 materials are reported.

2. The abstracts presented were submitted by the following companies as a partial requirement of various data compilation contracts sponsored by the Information Processing Section of the Materials Applications Division:

Bell Aerosystems
The Boeing Company (All Divisions)
Chance Vought (Aeronautics)
General Dynamics (Convair/Fort Worth)
General Dynamics (Astronautics)
McDonnell Aircraft
North American Aviation
The Northrop Corp (Norair)
Republic Aviation
Solar Aircraft

The companies are identified on each abstract either by their name or by a code in the upper right hand corner. The North American Aviation and Norair abstracts are identified by code numbers prefixed by NA and NOR respectively. The abstracts from Convair/Fort Worth are identified by the letters FFR and those from Astronautics by the abbreviation GDA in the upper right hand corner.

3. The abstracts are arranged in sequential order based on their assigned index numbers. Each index number appears in the lower "outside" corner of the abstract page.

4. The index itself is made up of four sets of terms. The first set of terms is strictly on materials, the second on properties, the third on processes and the fourth set consists of miscellaneous terms such as antennas, O-rings and space

vehicles. The terms in each set are basically listed in alphabetical order. However, it should be noted that the materials terms are primarily lumped alphabetically into predetermined categories which in turn are arranged in alphabetical order. For instance, materials such as Eastman 910 and RTV-88 are listed under adhesives since they are considered as adhesives. Such an arrangement was decided for two major reasons. First, it simplifies the handling of composite materials. Also, it obviously helps those who are interested in finding something in materials areas as well as specific materials. To keep the materials list as simple and straightforward as possible, cross references were not used on specific materials terms, but only on the major categories.

5. The abstracts presented in this report give some limited indication of the non-metallics R&D programming in effect at several companies. The intent of this presentation is to allow some further exchange of information on a voluntary basis. In those cases where more information or an exchange of information is desired, contact should be made with the appropriate company giving sufficient identification to the material of interest. The company addresses are:

Bell Aerosystems Co.
Attn: J. M. Nowak (Ref: Contract AF33(657)-8555)
Buffalo 5, N. Y.

The Boeing Co.
Aerospace Div.
Attn: J. W. Smuin (Ref: Contract AF33(616)-7559)
Seattle, Washington

General Dynamics Corp.
Convair/Astronautics Div.
Attn: J. E. Chafey (Ref: Contract AF33(616)-7984)
P. O. Box 1128
San Diego 12, Calif.

General Dynamics Corp.
Convair/Fort Worth Div.
Attn: A. A. Lanzara (Ref: Contract AF33(657)-7248)
Box 748
Fort Worth 1, Texas

McDonnell Aircraft Corp.
Attn: H. J. Siegel (Ref: Contract AF33(657)-7749)
P. O. Box 516
St. Louis 66, Missouri

North American Aviation, Inc.
Attn: R. L. Schleicher (Ref: Contract AF33(616)-8009)
International Airport
Los Angeles 45, Calif.

The Northrop Corp.
Norair Div.
Attn: G. A. Nelson (Ref: Contract AF33(616)-8140)
Hawthorne, Calif.

Republic Aviation Corp.
Attn: R. McCaffery (Ref: Contract AF33(616)-8084)
Farmingdale L. I., N. Y.

Solar Aircraft Co.
Research Laboratories
Attn: J. W. Welty (Ref: Contract AF33(616)-8375)
San Diego 12, Calif.

Chance Vought Corp.
Aeronautics & Missiles Div.
Attn: G. A. Starr (Ref: Contract AF33(616)-7986)
P. O. Box 5907
Dallas 22, Texas

III. CONCLUSIONS: None

IV. RECOMMENDATIONS: None

COORDINATION:

EDWARD DUGGER, ASRCE-31

PREPARED BY:

GEORGE YOUNG, ASRCE-31

PUBLICATION REVIEW

This report has been reviewed and is approved.

D. A. SHINN
Chief, Materials Information Branch
Materials Applications Division
Air Force Materials Laboratory

DISTRIBUTION

ASRC (Mr. Lovelace)
ASRCE (Maj. Postelnek)
ASRCE-3 (Mr. Shinn)
ASRCE-2 (Mr. Conrardy)
ASRCE-22 (Mr. Olevitch)
ASRCE-31 (Mr. Dugger)
ASRCE-31 (Mr. Klinger)
ASRCE-31 (Mr. Young)
ASRCE-31 (Library (300 cys)
ASRCE-32 (Mr. Emrick)
ASRCM (5 cys)
ASRCN (5 cys)
ASRCP (5 cys)
ASRCT (5 cys)

APPENDIX I

(INDEX)

MATERIALS TERMS

PROPERTY TERMS

PROCESSING TERMS

OTHER PERTINENT TERMS

APPENDIX II

ABSTRACTS

1. MATERIAL CLASSIFICATION: Plastic Materials

2. TITLE: Physical and Electrical Properties of Scotchcast No. 8 Resin

3. OBJECTIVE:

A limited evaluation program was conducted to determine a number of physical and electrical properties of Scotchcast No. 8 resin system.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The average of several test sample results on Scotchcast No. 8 resin cured per the manufacturer's recommendations are presented as follows:

Dielectric Constant	
0.1 kcps	4.63
1 kcps	4.04
10 kcps	3.75
100 kcps	3.57
Dissipation Factor	
0.1 kcps	0.1005
1 kcps	0.0645
10 kcps	0.0431
100 kcps	0.0332
Dielectric Strength (volts/mil)	313
Volume Resistivity (Ohm-cm)	
Dry	5.3×10^{12}
Wet (10 days 70 C)	8×10^{9}
Thermal Conductivity (cal/sec/cm^2/C°/cm)	4.7×10^{-4}
Moisture Absorption (24 hrs 25 C)	1.17%
Specific Gravity	1.166
Thermoshock (MIL-I-16923, Type C)	Passed

Scotchcast No. 8 resin system (supplied by Minnesota Mining & Manufacturing Company) is easy to handle. The cured polymer is flexible and passes thermoshock cycling.

This work was sponsored by Autonetics.

NA-61-1049-1
11-1-61

1. MATERIAL CLASSIFICATION: Plastic Materials

2. TITLE: Physical and Electrical Properties of Scotchcast No. 247 Resin System

3. OBJECTIVE:

An extensive evaluation program was conducted to determine the physical and electrical properties of Scotchcast No. 247 resin system.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The average of several test sample results on Scotchcast No. 247 resin system cured per the manufacturer's instructions are presented as follows:

Specific Gravity	1.59
Hardness, Shore D	60
Gel Time 250 F (minutes)	26-27
Volume Shrinkage (percent)	2.48
Dielectric Constant	
23 C 1000 Cycles	4.08
1 Megacycle	4.23
10 Megacycles	4.01
105 C 1000 Cycles	5.4
130 C 1000 Cycles	5.4
155 C 1000 Cycles	5.2
Dissipation Factor	
23 C 1000 Cycles	.043
1 Megacycle	.038
10 Megacycles	.032
105 C 1000 Cycles	.043
130 C 1000 Cycles	.038
155 C 1000 Cycles	.100
Volume Resistivity (Ohm-cm)	
Dry	4×10^{13}
Wet	3.8×10^{10}
Dielectric Strength (volts/mil)	730
Thermal Conductivity (ca/sec/cm^2/C°/cm)	6.5×10^{-4}
Moisture Absorption (percent, 24 hrs 23 C)	0.43

Scotchcast No. 247 resin system (supplied by Minnesota Mining & Manufacturing Company) is easy to handle, giving a cured flexible polymer which does not support combustion.

This work was sponsored by Automatics.

1. <u>MATERIAL CLASSIFICATION</u>: Plastics

2. <u>TITLE</u>: Selection of a Low-Loss Heat Resistant Radome Laminate

3. <u>OBJECTIVE</u>: Mechanical strength tests are being conducted on all low-loss commercial resins at room temperature, 210F, 300F, and 350F. The loss tangent and dielectric strength of each laminate has been measured.

4. <u>ABSTRACT OF RESULTS OR CONCLUSIONS</u>:

Several laminates have exhibited low loss characteristics at the 9.375 KMC frequency with good heat resistance up to 300F.

Resin	Reinforcement	Flexural Strength (Ksi) (One Hour Exposure) (r.t.)	(210F)	(300F)	Electrical Measurements (Dielectric)	(Loss Tangent)
P-680	181 glass cloth	67.8	60.1	50.5	4.22	.008
P-680	581 quartz cloth	38.6	35.2	31.5	3.86	.005
Dapon 35	181 glass cloth	74.3	66.8	56.3	4.22	.010
Atlac L-382	181 glass cloth	67.1	-	31.2	Not Complete	
F-131-11	181 glass cloth	41.8	29.1	24.3	4.23	.006

Further investigation indicates materials will be found with better electrical properties; e.g., Buton A-500, a petrochemical polyester resin

This work is Company-sponsored, and is approximately 75% complete. The program is being conducted by the Columbus Division and is extensive.

MA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Plastics

2. TITLE: Evaluation of New Multipurpose Environmental Isolation Material

3. OBJECTIVE:

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Completion scheduled for May 1962

Physical properties of flexibly polyester urethane foam in approximately 2, 4, 6 and 8 lb./ft.^{3} densities and 1/2, 3/4, 1, 1 1/4 and 1 1/2 inch thicknesses were tested at room temperature, -65, 100, 150, 200 and 250F.

Compressive and tensile strengths of the foam were considerably greater at sub-zero temperatures than at room temperature. At 250F, compressive strength was slightly lower than at room temperature. Tensile values dropped off appreciably between these same temperature limits. Set took place, expecially in the lower density specimens on continued exposure to temperature and compression loading. Most of the compression set disappeared when specimens were reheated in the no-load condition. Long term exposure to 250F resulted in no dimensional change of the urethane. All of the foams tested were judged "non-burning" per ASTM D635-56T.

This work was performed under sponsorship of the United States Naval Air Development Center by the Columbus Division and constitutes an extensive program.

1. MATERIAL CLASSIFICATION: Plastics

2. TITLE: Comparing Fabrication Techniques and Physical Properties of Vibrin 136A and Phenyl-Silane Glass Fabric Laminates for Use at 550° F

3. OBJECTIVE:

The purpose of this extensive research effort was to determine which material should be used to fabricate nose fairings for high temperature air vehicles. Supplier information indicates that phenyl silane laminates are stronger for long exposure periods at 550° F but that vibrin 136A laminates are much simpler to fabricate.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Two panels, 4' x 4' x 0.4", were fabricated using vibrin 136A and SC-1013 phenyl silane.

The phenyl silane panel developed a large blister (approximately 1 sq. ft. in area) during post-cure. This confirmed the suspicions that phenyl silane is an extremely difficult material to fabricate in sections over 1/8" in thickness. Flexural testing of the acceptable portions of the laminate yielded extremely low results due to premature failure the adhesive bond layer in the phenyl silane panel under sheer loads.

The vibrin 136A panel proved to be easy to fabricate and exhibited satisfactory behavior at room temperature and at 550° F.

This work was performed at the Los Angeles Division under U.S.A.F. sponsorship.

1. MATERIAL CLASSIFICATION: Plastics

2. TITLE: Testing of Non-Metallic Materials at Cryogenic Temperatures.

3. OBJECTIVE:

An extensive effort to determine selected mechanical and physical properties of various plastics at -320°F and -423° F. These determinations will provide data suitable for the design of cryogenic components. Property determination of all the materials at 77°F will provide a basis for comparison.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The materials tested include:

1. Kel-F (low, medium and high crystallinity).
2. Teflon TFE (low, medium and high crystallinity).
3. Glass Filled Teflon TFE.
4. Bronze Filled Teflon TFE.
5. Asbestos Filled Teflon TFE.
6. Graphite Filled Teflon TFE.
7. Glass Fabric - Teflon TFE Laminate.
8. Teflon FEP (low and high crystallinity).
9. Glass Filled Teflon FEP.
10. Glass Fabric - Teflon FEP Laminate.
11. Mylar (as received and hot formed).
12. Nylon.

The properties determined include:

1. Tensile yield, ultimate, modulus and elongation.
2. Flexural ultimate and modulus.
3. Compressive ultimate and modulus.
4. Notched Izod impact strength
5. Torsional modulus.
6. Coefficient of thermal expansion.
7. Density.
8. X-ray diffraction pattern.
9. Simulated diaphragm testing.

Particular attention is being paid to the effect of processing on crystallinity. Typical data showing the effect of crystallinity on two materials is as follows:

Material	UTS-KSI R.T.	UTS-KSI -320°F	UTS-KSI -420°F
Kel-F - Low Crystallinity	5.4	24.9	28.9
Kel-F - Med Crystallinity	5.9	17.2	20.7
Kel-F - High Crystallinity	4.6	15.7	18.0
Teflon FEP - Low Crystallinity	4.5	17.9	24.0
Teflon FEP - High Crystallinity	3.4	17.9	23.6

These data show the relatively slight effect of crystallinity on cryogenic properties of Teflon FEP as compared to Kel-F.

This work is 75% complete and is done by Rocketdyne and sponsored by USAF Directorate of Rocket Propulsion, EAFB.

MA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Plastics

2. TITLE: Physical and Electrical Properties of Dow Corning's Sylgard 182 Resin

3. OBJECTIVE: A limited evaluation program was conducted to determine the physical and electrical properties of Sylgard 182 Resin. The values were obtained using ASTM, Military Specification, or Federal test method.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Property	Test Method	Result
Viscosity at 23 C	Brookfield	4,460 CPS
Exotherm	50 CC Mixture	None
Volume Shrinkage	ASTM	1.036 percent
Specific Gravity	ASTM	1.045
Hardness (Shore A)	ASTM	40
Lap Shear (Primed Surface)	Fed. Test Method	620 PSI
Dielectric Strength	Mil-I-16923C	467 V/Mil
Volume Resistivity		
Dry	Mil-I-16923C	6.48×10^{14} ohms/cms
Wet	Mil-I-16923C	3.17×10^{13} ohms/cms
Dissipation Factor	ASTM	
100 cycles		0.0009
1 kc		0.0009
10 kc		0.0011
100 kc		0.0008
Dielectric Constant	ASTM	
100 cycles		2.98
1 kc		2.98
10 kc		2.98
100 kc		2.98
Flammability	Mil-I-16923C	Self Ext.
Heat Resistance (weight loss)	Mil-I-16923C (Type C)	1.51 percent
Thermal Shock	Mil-I-16923C (Type D)	Passed
Water Absorption	ASTM	0.04 percent

This work was sponsored by Autonetics.

NA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Plastic Laminate

2. TITLE: Compressive Properties of Glass Fabric-Epoxy Resin Laminates

3. OBJECTIVE:

A limited investigation was undertaken to determine the compressive load-carrying capacity of 143 glass fabric reinforced E787 epoxy resin laminates at R.T., 200F, 300F, and 500F.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Results of tests upon the laminate specimens to determine ultimate compressive strength indicate a reduction in strength, from room temperature, of approximately 50 percent at 200F, 88 percent at 300F, and 91 percent at 500F.

This work was performed at S&ID of NAA in connection with an Air Force Contract.

MATERIALS RESEARCH PROJECT SUMMARY

GDA

Period:	1 March 1961 to 1 September 1961
Material Classification:	Mechanical Properties of Non-Metallic Materials
Materials:	Kel-F, Teflon
Title:	A Study of Modified Fluorocarbon Plastics.
Project No.	REA 111-9109
Objective:	To investigate the relationship between crystal structure and mechanical properties of fluorocarbon plastics, to develop rapid non-destructive evaluation methods, and to modify these materials for specific uses.

Results and Conclusions:

X-ray and infra-red spectrophotometer graphs were made of fluorocarbons to characterize their crystallinities for comparison with their physical and mechanical properties. X-ray methods were found to be immediately applicable to chlorine containing fluorocarbons such as Kel-F. Chlorine is the heaviest constituent atom of fluorocarbons, hence more detectable by x-radiation. The net result is that Kel-F's crystallinity can be assayed with x-ray spectrophotmetry and then correlated to such tests as Knoop harness.

Mechanical property and physical property testing has been conducted on properly fabricated Teflon of crystallinities ranging from 40% to 60% at temperatures as low as 320°F. The major problem in this work is in the procurement of "properly fabricated" material. After defining the qualities of good material, sample quantitites have been manufactured under closely controlled conditions.

Stress-strain information on low, medium, and high crystallinity materials has been collected to -320°F and load-deflection testing for gasket applications has been conducted at room temperature. Stress-strain testing has supplied design data which reveals a low percent elongation at -320°F of 1.25 percent. DuPont data, which has been previously relied upon specifies 5% at -320°F. This deviation could explain difficulties experienced with some spring loaded seals. Test results are also dependent on sample thickness, a factor not accounted for in design data. Testing to -420°F for two thicknesses of Teflon of low, medium, and high crystallinity will be described in a final report for this project.

Compounding of fluorocarbon resins with ground reagent grade titanium dioxide pigment for use as a nondeteriorating high absorptivity/emissivity ratio coating for aerospace use is in progress. Pennsalt Chemical Company's vinylidene fluoride resin appears promising and is being compounded with various solvents and ground with a ball mill into a pigmented dispersion. Difficulties have been experienced in finding a suitable solvent system that does not discolor during heat cure. Preliminary investigations indicate that dimethylacetamide will obviate this difficulty.

Index No. 244

MATERIALS RESEARCH PROJECT SUMMARY

Period: January 1962 to 1 March 1962 GDA

Material Classification: Plastics and Adhesives

Materials: Selection open

Title: Self-Rigidizing and Ultra-Light-Weight Structures

Project No: REA 111-9311

Objective: To develop new and better methods for the erection and self-rigidization of inflatable space structures. It is the aim of the program to develop single layer construction to replace the present double wall structures and to establish a more reliable rigidizing system to replace the present foaming approach. A material is also being considered which could be used in the erection and rigidization phases and subsequently by removed by sublimation.

Results and Conclusions: An extensive literature survey has been conducted to more thoroughly acquaint the researchers on present methods for accomplishing the proposed task. Information was also accumulated on similar programs being conducted by other firms. Considerable data were obtained from previous reports on the effects of high vacuum and high-intensity ultra-violet radiation on polymeric materials.

A laboratory set-up was prepared to determine the effect of these two variables on materials and systems suggested for consideration. Some preliminary data have been obtained.

MATERIALS RESEARCH PROJECT SUMMARY

Period: January 1962 to 1 March 1962 GDA

Material Classification: Plastics and adhesives

Materials: Various organic plastics and elastomers

Title: Properties of Organic Materials in Space Environments

Project No: REA 111-9306

Objective:

1) To determine the deleterious effects of space environments on plastics and elastomers.

2) To improve the performance of these materials by modifying composition and structure.

Current Status:

A comprehensive literature survey of reports of recent investigations in this field has been initiated.

Plans have been devised for exposing test specimens to high vacuum and ultra-violet light irradiation.

MATERIALS RESEARCH PROJECT SUMMARY

Period: January 1962 to 1 March 1962 GDA

Material Classification: Physical Properties of Metals and Non-Metals

Materials: Selection open

Title: Thermal Expansion of Space Vehicle Materials

Project No: 111-9303

Objective: To investigate low temperature thermal expansion characteristics of plastics, ceramics, and metals which show promise of use in future space vehicles.

Current Status: A cryostat originally used for low temperature tensile testing has been rebuilt to provide a low boil-off liquid hydrogen bath for the quartz tube dilatometer.

The low temperature furnace for the Leitz dilatometer was modified to provide an interior heater instead of an exterior heater. Several trial runs indicated a power requirement 60% less than that which was necessary with the original winding. This will also result in saving approximately 60 liters of liquid nitrogen per run.

1.0 Index Code . . . . (Plstc-23Fc)(II-c)(V-i)
(Plstc-20FC)(II-c)(V-i)

2.0 Title - T.R. No. 513-246, Electrical Potting Compounds - Surface and Volume Resistivity at Elevated Temperatures for Protracted Times.

3.0 Objective - The electrical and electronic circuitry in high performance aircraft, missiles, and space vehicles demands the usage of potting compounds that exhibit the following characteristics:

a. Complete resistance to moisture.

b. Impervious to extraneous materials.

c. Load supporting capability for bundles of electrical wires.

d. Good electrical resistance at elevated temperatures.

The scope of this test program includes the following:

a. Surface and volume resistivity measurements of various electrical potting compounds at exposure temperatures from room temperature through 600°F for 1/2 hour to 1000 hours.

b. Observance of any deterioration of potting compounds during or after the tests.

c. Observance of any adhesion of potting compounds to connectors and wires both before and after elevated temperature exposure.

4.0 Status and Results - Approximately 95% of the surface and volume resistivity tests at elevated temperatures have been completed. The test results thus far indicate that General Electric Corporation's RTV-60 and Minnesota Mining and Manufacturing Company's EC-1663 perform better than Coast Pro-Seal 777 and Product's Research PR-1525 with regard to surface and volume resistivity at elevated temperatures of 300°F and 500°F for time intervals of 1/2 hour to 1000 hours.

1.0 Index Code . . . . (Plstc-20 FC)(V-i)

2.0 Title - T.R. No. 513 246.01, Electrical Potting Compounds - Surface and Volume Resistivity at Elevated Temperatures for Protracted Times.

3.0 Objective - To determine the adhesion characteristics of silicone RTV potting compounds relative to MIL-W-16878 type E Teflon hook-up wire and W. L. Gore type AR Teflon hook-up wire. The scope of this test program includes the following:

a. Adhesion testing of the potting compound to the wires on two samples of each type of specimen at room temperature, after 24 hours exposure to 500°F (while still hot), and upon cooling to room temperature.

b. Potting-wire adhesion testing to failure of various potting-wire junctions. Ascertain whether the failure is adhesive, cohesive, or a combination of the two.

4.0 Status and Results - This test program is nearing completion. Test results indicate that Hughson primer is superior to EC-1694 primer in adhesion to etched wire, especially at room temperature. Both primers exhibited poor adhesion to etched Teflon wire when tested at 500°F for 24 hours. However, adhesion capabilities did return after specimens were cooled to room temperature. This test also indicates that either Thermolite 12, RTV-9910 or RTV-9930 catalysts can be used without affecting the basic adhesion and strength properties of the RTV-60 potting compound material.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; EPOXY FURANE RESIN; METAL FILL MOLD DIE

DESCRIPTIVE TITLE:

Investigation of Plastic Mat Mold Die Fabricated by Furance 10Q High Temperature Gel-Coat and 10P High Temperature Bonding Resin

OBJECTIVE:

Fabrication and evaluation of a high temperature metal-fill plastic mat mold die.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Reynolds #200 aluminum powder is not satisfactory due to heat-transfer problems as a filler material with epoxy resins. Considerable warpage occurred due to a large temperature gradient. The temperature resistance of 10Q and 10P is satisfactory. Parting difficulties were reduced considerably as a result of the surface finish of the plastic die. Less flow-time was required for the construction of the plastic die. Although many improvements were noted in the plastic die, the existance of warpage precludes acceptance of this material for this purpose.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; EPOXY; TUBING DEVELOPMENT

DESCRIPTIVE TITLE:

Investigation of Manufacturing Aspects of Epoxy Tubing

OBJECTIVE:

Investigation of fabrication problems, costs, and the dimensional stability of epoxy tubing in varying environments and conditions.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Upon completion of testing, it was determined that this material did not perform as expected, thus limiting its use for close dimensional purposes. The great variation in deflection in the temperature range from 60° to 120°F in both loaded and not loaded conditions disclosed a definite design limitation.

The study of fabrication techniques and a review of the potential manhour reduction available through the use of this type tubing and fittings, pointed out the necessity for further investigation of other high heat resistant resins for this type of construction. Epoxy tubing can be easily assembled in the shop and fabrication hours required may be reduced through the use of this tubing and the associated prefabricated fittings in tooling, scaffolding, etc. or in lieu of steel or aluminum tubular structures of appropriate size.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; PARAPLAST #33; EXPENDABLE MANDREL

DESCRIPTIVE TITLE:

Determination of Capabilities and Qualities of Paraplast #33 as an Expendable Mandrel Material

OBJECTIVE:

Determine manufacturing economy of fabricating mandrels from Paraplast #33 for possible reduction of mandrel removal time, reduction in handling time, flow-time, transportation costs, etc.

ABSTRACT OF RESULTS AND CONCLUSIONS:

It was concluded that Paraplast #33 is less expensive in over-all costs (total costs are higher but are off-set by re-usability of material and manhour reduction in mandrel removal).

Flow-time is considerably reduced by the use of Paraplast #33 (because of the reduction of time required in the preparation and removal of the mandrel.)

More complicated parts may be fabricated without mandrel removal problems (parts not considered economical using break-away type plaster mandrel materials).

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; POLYVINYL CHLORIDE; MOBILE MISSILE HARNESS

DESCRIPTIVE TITLE:

Mobile Missile Harness - Minuteman

OBJECTIVE:

To locate or develop materials which meet specific load-deflection requirements for the continuous support harness for the mobile concept of the Minuteman Missile.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Several types of rubber and flexible plastic material configurations were tested, to determine their load-deflection characteristics, this included the following: Neoprene rubber, BMS 1-11 grades 40 and 60 (molded in various configurations such as waffle and ripple shapes), sponge and foam rubber, and polyvinyl chloride honeycomb.

All of these materials varied a great deal in load-deflection characteristics. The materials such as foam and sponge were quite stable and exhibited a very steady rise in the psi required to obtain specific deflections. The hardness or density of the material was the determining factor in the slope of the load versus deflection curve. The polyvinyl chloride honeycomb and the waffle configurations of the BMS 1-11C Neoprene rubber had quite different characteristics than those of sponge and foam or solid slab rubber. The initial load versus deflection curve was comparable to those of the sponge and foams only up to the point where the column strength of the vertical webs gave way to buckling. At this point the force required to deflect the specimen remained almost constant until the material in its crashed state again began to compress and the load required to deflect the material increased rapidly. The thickness of the web or column and the hardness of the material was the determining factor in this case. BMS 1-11 grade 40 molded in a waffle shape 1/2" thick met the desired load deflection requirements.

Index No. [illegible]

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; TAPE 3-M#471; CHEMICAL MILLING MASKING

DESCRIPTIVE TITLE:

Evaluation of 3-M #471 as a Stop-Off Material for Potential Use in Masking Areas Prior to Anodizing

OBJECTIVE:

To test the natural practice 3-M #471 for the purpose stated.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The material evaluated is not satisfactory (it poses difficulties in that it is only suitable for flat surfaces). The present material "lead-back" tape is adequate for flat surfaces; improvements are needed. A material that may be cut and formed to other than flat surfaces, without premature release or peel back.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; FILAMENT WOUND FIBERGLASS; PRESSURE BOTTLES

DESCRIPTIVE TITLE:

Development of Nose-Air and Ramjet Pressure Bottles - Bomarc, IM-99B

OBJECTIVE:

To develop a filament wound fiberglass pressure bottle to store air at 3000 psi and to have a hydrostatic burst pressure of 9,450 psi.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A winding process was devised for the fabrication of an 8-foot long cylindrical vessel to be used as a supply of air for operating instruments and feeding fuel in the IM-99B. The bottle was to be wound directly on its butyl rubber liner. Appropriate material and process specifications and construction documents were issued.

Using this process, bottles were developed which would meet mechanical and physical design requirements under operating conditions and yet which would be at least 10 pounds lighter than aluminum bottles of similar design. Basic achievements were the production of filament wound bottles capable of meeting leakage rate restrictions and the minimum short time hydrostatic burst pressure of 9,450 psi. Use of these bottles is being detained until long term storage behavior can be defined.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; LOW TEMPERATURE ABLATABLE PLASTIC-METAL LAMINATES

DESCRIPTIVE TITLE:

Electromagnetic Ground Plane, Ablatable

OBJECTIVE:

To develop an electromagnetic ground plane for the Azusa system compatable with the ablatable insulation.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Laminates of various configurations of expanded and perforated aluminum foils combined with acrylic and epoxy-polyamide resins were fabricated and tested. The electronic tests included VSWR and transmissivity determinations and full-scale antenna pattern tests. The ablative properties were determined under exposure to "plasma jet" and rocket exhaust gases. The most satisfactory laminate was composed of sheets of .001 inch thick aluminum foil perforated in a square pattern with 3/16 inch holes on 5/16 inch centers and.025 inch of epoxy-polyamide resin between the foil sheets.

Details are reported in BAC documents D2-5202-1, D2-6759 and Process Specification BAC 5400.

MA-61-1049-1
11-1-61

1. MATERIAL CLASSIFICATION: Composite (Metallic-Non-Metallic)

2. TITLE: Axial Core Shear Fatigue of Honeycomb Sandwich, Ti Alloy Facing Sheets and Phenolic Impregnated Glass Cloth Core, at -300°F.

3. OBJECTIVE:

Under a limited program, specimens of honeycomb sandwich composed of facings of 0.025 inch thick Ti alloy 5Al-2.5Sn adhesive bonded to 0.625 thick Hexcel HRP 3/16 GF-4.5 pound density core (not foam filled) were axial core shear fatigue tested at -300F. The adhesive system was FM-1000 without carrier. Metal parts were primed with Bloomingdale 1009 Prime. The tests were conducted under simulated conditions that might be encountered in structures at cryogenic temperatures.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Static shear tests at -300F established an average ultimate shear load of 4,090 pounds. Cyclic tests at -300F were run at maximum loads of 90% and 95% of the average static ultimate shear strength for 3000 cycles after which the specimens were statically tested to failure. Failing loads of fatigued specimens averaged higher than those of specimens statically tested without prior fatigue.

This work was done at the S&ID of NAA and was Company-Sponsored.

Index No. 257

1. MATERIAL CLASSIFICATION: Composite (Metallic-Non-Metallic)

2. TITLE: Facing Sheet Tensile, Sandwich Flatwise Compression, Sandwich Block Shear and Sandwich End Compression Tests at Room Temperature.

3. OBJECTIVE:

In order to evaluate the effect of internal foam on the stability of the facing within the cell of honeycomb sandwich structure, facing tensile, sandwich end compression, sandwich flatwise compression and sandwich block shear tests were conducted at room temperature under a limited program.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The sandwich was composed of the following:

1. Facing sheets - Titanium B120VCA, 0.007 in. thick, heat aged for 72 hours at 900F in vacuum.

2. Core - Hexcell fiberglass HRP 3/8-in. cell, 4.0 lb density, 5/8 in. thick.

3. Adhesive - HT424 adhesive with carrier.

4. Foam - CRP International 1021-2 foam to fill honeycomb core. Used on half the specimens.

The average tensile properties of B120VCA titanium 0.007 gage sheet, solution annealed and heat aged 72 hours in vacuum were 184,700 psi ultimate strength, 0.5% elongation and amodulus of elasticity of 16.9×10^6 psi.

Results of flatwise compression tests on unfoamed specimens of sandwich averaged 596.7 psi ultimate stress and 61,600 psi modulus; the foamed specimens averaged 918.7 psi ultimate stress and 80,400 psi modulus.

Results of block shear tests on unfoamed specimens of sandwich averaged 251.1 psi ultimate stress and 10,700 psi modulus; the foamed specimens averaged 381.7 psi ultimate stress and 14,300 psi modulus.

End compression tests on unfoamed specimens of sandwich averaged 5,590 lbs ultimate load; the foamed sandwich specimens averaged 5,720 lbs ultimate load.

All specimens were tested at 70F.

This work was done at S&ID of NAA and Company-Sponsored.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

FOAM, POLY-ETHER URETHANE, SPRAYED

DESCRIPTIVE TITLE:

Spray Application of Insulation to Interior of Minuteman Transporter-Erector Van

OBJECTIVE:

To provide an insulation system for environmental control inside the van.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The interior of the van is being sprayed with a low-density (2 - 2.5 lb/ft^3) polyurethane foam to various thicknesses from .5 to 2.5 inches.

The surface of the foam in the lower area is sprayed with chopped fiberglass roving and iso-phthalic resin for abrasion resistance and to distribute walking loads. The upper foamed areas are sprayed with "Hypalon", a synthetic rubber coating, for resistance to handling damage.

The materials and processes are documented in Boeing Specifications, BMS 8-38 and BAC 5434.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, CELLULAR FOAM; EVALUATION, SPECIAL APPLICATION

DESCRIPTIVE TITLE:

Cellular Foams for Fuel Cell Float Valves

OBJECTIVE: Various cellular plastics were screened and evaluated for possible use as a float material in JP-4 fuel.

ABSTRACT OF RESULTS AND CONCLUSIONS:

One epoxy and two urethane foams were screened on the basis of absorption of MIL-H-3136, Type III fluid. The most promising foam, a urethane, was tested further to determine resistance to erosion or deterioration from sloshing in JP-4 fuel, solubility in JP-4 fuel, and resistance to vibration at resonance. All conditions were found to have a negligible effect and the material has been put into use as the float for fuel cell float valves on the B-52 airplane.

2-5546-0-9

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, EPON 828 RESIN; VISCOSITY DILUENTS, INVESTIGATION

DESCRIPTIVE TITLE:

Diluents for Epon 828 Resin

OBJECTIVE:

The purpose of this program was to find a suitable diluent or diluents that could be mixed with Epon 828 Resin for the purpose of lowering its viscosity without degradation of the resin as far as affecting the mechanical and physical properties of the end product laminates.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Diluents are low viscosity, free flowing liquids, used to reduce the viscosity of the resin so that better penetration in casting and better wetting ability in laminates and adhesive formulations may be achieved.

Epon 828 is a commonly used epoxy resin. However, it is difficult to use when using the wet lay-up technique, because of its high viscosity. Therefore, various diluents were mixed with the resin to lower its viscosity. The diluents used were Limonene Dioxide, Syl-Kem 90, Mod-Epox, and Vinylcyclohexene Dioxide.

It was found that Syl-Kem 90 and Vinylcyclohexene Dioxide could be used with Epon 828 without degradation of subsequent laminate mechanical and physical properties. The elevated temperature properties of the resin were improved. It is recommended that Vinylcyclohexene Dioxide be used as a diluent rather than Syl-Kem 90 because of the difference in price which is approximately $10.00 per pound.

2-5546-0-9

MATERIALS PROGRAM ABSTRACTS

21 ... 1

MATERIAL CLASSIFICATION:

PLASTIC, FILAMENT WOUND CYLINDER; MECHANICAL PROPERTIES, EVALUATION OF

DESCRIPTIVE TITLE:

Material Properties - Filament Wound Cylinders

OBJECTIVE:

To determine mechanical properties of filament wound material.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Plastic cylinders made with Epon 828 resin and reinforced with 143 glass cloth and glass roving were fabricated. The material was tested for bolt bearing, interlaminar shear and edgewise compression at room temperature and at 500°F.

	Stress in PSI	
Test	70°F	500°F
Bolt Bearing	40,3000	2,740
Interlaminar Shear	5,210	288
Edgewise Compression	38,700	2,110

Axial compression tests of three 17 inch diameter cylinders with 0.075" wall gage indicated an average buckling stress of 13,800 psi at room temperature.

2-5546-0-9

Index No. 262

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, FOAM, EPOXY AND URETHANE; ENVIRONMENTAL EXPOSURE STUDIES

DESCRIPTIVE TITLE:

Effect of Moisture and Weather of Foam

OBJECTIVE: The aim was to determine if epoxy and urethane foam deteriorated substantially due to weathering and if incorporation of a U.V. absorber would improve weather resistance.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Using compressive properties as criteria, it was found that water in the form of high humidity or total immersion had the greatest effect on the strength. The effect was slightly more pronounced with the epoxy and it absorbed the greatest percentage of water. Sunlight or ultra-violet radiation caused a darkening of surface dolor and made the surface more friable. Use of carbon black lessened the effect. In no instance was the strength reduced by as much as 10%.

2-5546-0-9

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

21 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, POLYETHYLENE; THERMAL CHARACTERISTICS

DESCRIPTIVE TITLE:

Ablation Technology Research Chemistry of Polyethylene Decomposition

OBJECTIVE:

To determine the effect of crosslinking on the thermal behavior of polyethylene

ABSTRACT OF RESULTS AND CONCLUSIONS:

Linear and branched polyethylene samples were crosslinked and subjected to chemical and thermal tests.

Crosslinking was accomplished by chemical methods and by radiation.

Thermogravimetric, differential thermal, and infra-red analyses, melting points, and carbon and hydrogen analyses were obtained.

As a result of chemical crosslinking, the melting points of some polyethylenes have been raised so that the melting point and decomposition point approach the same temperature. The derived kinetic expressions of the decomposition are consistent with each other and compare favorably with the results on similar materials reported in the literature.

2-5546-0-9

Index No. 264

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, POLYMER, HEAT RESISTANT; SYNTHESIS DEVELOPMENT AND TESTING

DESCRIPTIVE TITLE:

Synthesis of Heat Resistant Polymers

OBJECTIVE: To develop new polymers, derived from silanes, phosphines, and phosphine oxides, possessing increased heat stability, and to test the properties of these polymers.

ABSTRACT OF RESULTS AND CONCLUSIONS:

p-Epoxyethylphenyltrimethylsilane was prepared and polymerized, with typical epoxy curing agents. Bis- (p-epoxyethylphenyl)dimethylsilane could not be prepared. The polymers produced had poor heat stability.

Mono-, di-, and tri-p-glycidyloxy derivatives of triphenylphosphine oxides were prepared and polymerized by conventional epoxy curing agents. The polymers had heat stabilities equivalent to conventional epoxy resins.

Polymers were prepared by reacting formaldehyde with mono-, di-, and tri-hydroxy triphenylphosphine. No useful products were obtained.

Resins were produced by condensing organosilicon isocyanates with silane diols and with the hydroxyphenylphosphine oxides. Some products with high heat stability but poor physical properties were produced.

The results of this work are contained in the Boeing Document D2-10240 "Heat Stable Organic Materials". The synthetic portions or the work were published in "Synthesis of Monomeric Silanes", J. Org. Chem. 25, 807 (1960) and "Derivatives of Triphenylphosphine and Triphenylphoshpine Oxide", J. Org. Chem. 25, 2001 (1960).

No polymers possessing properties superior to present commercially available products were developed.

2-5546-0-9

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, TANK LINER MATERIAL, LIQUID PROPELLANT; DEVELOPMENT OF

DESCRIPTIVE TITLE:

Development of a Liner for Filament Wound Liquid Propellant Booster Cases

OBJECTIVE:

To develop a liner for filament wound tanks for the containment of corrosive propellants.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A liner material, a Teflon (FEP)-aluminum-Teflon (FEP) laminate, was developed and its physical properties were determined.

A process was developed for the fabrication of the liner material.

Fabrication techniques were studied and a process was developed for the construction of the liner.

A process was developed for bonding the liner in the propellant tank.

D-5546-0-9

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

PLASTIC, TANK LINER, STORABLE LIQUID FUEL; PERMEABILITY STUDY

DESCRIPTIVE TITLE:

Permeability Study, Storable Liquids

OBJECTIVE:

The objective of this study was to determine the permeability rates of Arosine-50 and nitrogen tetroxide through several tank liner configurations, and the effect on the filament wound tank structure of that fuel or oxidizer which would permeate the liner.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Several liner configurations where tested for permeability by fuel (a 50-50 weight mixture of hydrazine and unsymmetrical dimethyl hydrazine) and oxidizer (nitrogen tetroxide). The most satisfactory liner configuration found was composed of a 2-mil chemically cleaned film of 2S or 3S aluminum laminated on each side with 5-mil Teflon FEP.

5-mils of Teflon FEP alone will provide a reasonably impermeable barrier to the fuel, but no practical thickness of FEP alone will provide any significant protection to the oxidizer tank material (a filament wound Fiberglass-epoxy resin structure) for more than a few hours.

The high peel strength liner laminates have low enough permeability rates to both fuel and oxidizer to provide tank protection for several months if temperatures remain below 70°F.

Any gross mechanical failure of the liners that allowed the fuel and oxidizer to wick together would result in the immediate destruction of the tank.

Once filled and emptied, the oxidizer tank liner will not be reusable if exposed to even normally moist air.

There is no significant difference in the liquid and vapor phase permeability rates of either fuel or oxidizer through 5-mil FEP at temperatures below 70°F.

Oct 61

Type of Program: Engineering Evaluation

Material Classification: Miscellaneous Special Purpose Materials

Descriptive Title: Wave Guide Window Material Tests

Objectives: To determine the dielectric constants and attenuation characteristics of high temperature radome materials.

Abstract of Results and Conclusions: The materials being evaluated include: Duroid 5650 end grain and flat grain (teflon reinforced with ceramic fibers), foamed Glas-Roc (expanded silica), fused silica 7940M, Pyroceram 9606, and a Republic proprietary composition (fiberous modified silicone).

Dielectric constants and attenuation characteristics have been determined at room temperature using a reflectometer and slotted line. The testing has been conducted in the frequency range of 8 to 10.5 kmc. Of the materials tested, the foamed Glas-Roc has exhibited the lowest dielectric constant and the lowest degree of attenuation.

Additional testing in the 1000°F to 2000°F temperature range is scheduled for the near future.

Oct 61

Type of Program: Engineering Evaluation

Material Classification: Plastics

Descriptive Title: Investigation of Acrylonitrile-Butadiene-Styrene (Royalite) Material for Non-Structural Aircraft Components

Objective: To evaluate the suitability of "Royalite" material for use in non-structural aircraft parts by determining impact strengths.

Abstract of Results and Conclusions: Charpy impact tests were conducted to determine the suitability of 1/8 inch thick Royalite in the temperature range of -70°F to +70°F. Previous studies have shown this type of material to be readily formable, low in cost, and of adequate intrinsic physical properties to function for the intended purpose. This test has shown that the low temperature impact properties of Royalite, which were not published, are sufficiently high to permit fabrication of satisfactory non-structural aircraft components.

Type of Program: Engineering Evaluation

Material Classification: Plastic

Descriptive Title: Abrasion Test of Electrical Tubing, Flexible Vinyl Insulation Sleeving, MIL-I-7444

Objective: To demonstrate that vinyl tubing would be satisfactory as a chafing protection in certain electrical sleeving application.

Abstract of Results and Conclusions: Testing was accomplished on a Taber Abraser. The vinyl material yielded an average weight loss of 0.15 gms after 3000 cycles using an H-22 wheel. Based on a comparison with neoprene rubber (MIL-R-6855 Class II, Grade 40), which has a published weight loss value of 5.9 gms when tested under similar conditions, the vinyl tubing is considered satisfactory.

Type of Program: **Engineering Evaluation**

Material Classification: **Plastics**

Descriptive Title: **Investigation of Out-Gassing of Isocyanate Foam Material**

Objective: **To determine the out-gassing characteristics of encapsulated and base isocyanate foams.**

Abstract of Results and Conclusions: The samples evaluated for out-gassing were bare polyester-urethane foam (Lock foam) block and the same type of block encapsulated in an epoxy-fiberglass laminate. The density of the foam used was 6.0 #/ft^3. Prior to testing and encapsulating, each of the samples was thoroughly dried in a desiccator. The blocks were exposed to a positive pressure of 1×10^{-3} mm of Hg for a minimum of 8 hours at 73 ±5°F. Out-gassing was determined by weight change. The bare foam block lost 2.1% of its weight compared to 0.02% weight loss for the encapsulated block.

Type of Program: Engineering Evaluation

Material Classification: Plastics

Descriptive Title: Dielectric Constant Measurements at Ka-Band Frequencies

Objective: To evaluate the dielectric characteristics of several plastic materials, with controlled resin content, as a function of Ka-band frequencies.

Abstract of Results and Conclusions: Dielectric measurements are being made with a Ka-band microwave bridge circuit (interferometer), assembled in accordance with the methods described in ARTC-4. The free space technique is being used in lieu of the shorted waveguide method. The shorted waveguide method requires dielectric samples to have close tolerances in order to accurately fit into the 0.28- by 0.14-inch Ka-band waveguide. Loss tangent characteristics are not being determined. Several one-foot-square fiberglass panels, manufactured by Republic Aviation, are being evaluated. These panels have been fabricated with various cloth types (164 and 181) and resin contents (42 to 47%). Material thickness has also been varied from two layers of cloth (.022 inch) to six layers of cloth (.072 inch). A teflon sample is being utilized as a standard because of its small variation in dielectric constant at room temperature, i.e., 2.10 at 100 cycles to 2.08 at 25 gigacycles as reported by A. R. Von Hippel in a 1954 M.I.T. publication "Dielectric Materials and Applications".

Dielectric constants are being obtained with the insertion phase difference (IPD) method through air with and without a sample. Typical dielectric constants at 38 gigacycles range from 2.068 to 2.087 for teflon, 3.527 to 3.581 for 181 cloth and 4.620 to 4.675 for 164 cloth. The entire Ka-band, from 26 to 40 gigacycles, is being surveyed.

Preliminary observations to date have pointed up the requirements for:

1). Close tolerances and critical adjustments at Ka-band frequencies due to the small wavelengths (7.5 to 11.3 millimeters).

2). Close control of frequency measurement due to klystron signal source frequency drift.

Type of Program: Engineering Evaluation

Material Classification: Plastics

Descriptive Title: Epon VIII, Crazing of Acrylics

Objective: Determine the effect of Epon VIII on acrylic materials.

Abstract of Results and Conclusions: Two acrylic materials, Plexiglas 1 and Plexiglas 55, were tested for compatibility with Shell adhesive Epon VIII. Compatibility was determined with an accelerated crazing test performed in accordance with paragraph 4.5.9 of MIL-S-7126d. The test procedure entailed loading a 1 x 7 x .025 adhesive coated specimen in flexure for 24 hours, maintaining a maximum fibre stress of 2000 psi. Both Plexiglas 1 and Plexiglas 55 showed no crazing effect upon completion of testing.

Type of Program: Processing Development

Material Classification: Plastics

Descriptive Title: Development of Plastic Mold Dies

Objective: To develop a casting resin formulation to enable the manufacture of self-heating mated dies for fabrication of reinforced plastic aircraft parts.

Abstract of Results and Conclusions: A number of commercially available casting resins, as well as newly formulated proprietary thermosetting resins, are being evaluated for use as self heated mated die materials. Commercial resins have included those available from Furane Resins & Coatings Company, Marbellette Corporation, Smooth-On Corporation, Ren Corporation, etc. The study of selected resins includes measuring thermal conductivity, heat distortion temperature, compression strength, and impact resistance.

To date, the most successful casting material was an aluminum filled anhydride cure epoxy-novalac resin. Investigation of effects of inert fillers, filler size and shape, curing agents, suspension agents, and casting techniques will continue until small scale tools appear feasible. At that point, an actual production die will be fabricated, and die life and cost data will be obtained.

Initial studies have shown that this technique of die manufacture is both feasible and economical.

Type of Program: **Processing Development**

Material Classification: **Plastics**

Descriptive Title: **Splining Plastic Resins for Mockups**

Objective: **To determine the suitability of thermosetting plastics for splined aircraft mockup.**

Abstract of Results and Conclusions: **Specially formulated epoxy resins are being evaluated for use as splining material. The physical parameters and characteristics such as viscosity, thixotropy, density and ease of handling are being determined.**

The most efficient formulation obtained will be used to build a full scale F-105D winglet mockup. This mockup will be compared to a conventional plastic mockup manufactured at the same time. The evaluation will consist of cost data, thermal stability, storageability, and surface accuracy.

It is anticipated that splining of plastic resins will be successful and will be superior to the plaster mockup from the viewpoints of dimensional stability, storageability, and useability.

Type of Program: Applied Research and Development

Material Classification: Non Metallics - General

Descriptive Title: Effect of Vacuum - UV Exposure On Materials

Objective: To determine changes in solar absorptance and weight loss associated with exposure of materials to high vacuum and ultraviolet irradation.

Abstract of Results and Conclusions: Both organic and inorganic materials are being evaluated. Typical materials being investigated are ZYTEL 101, NRC Mylar base Super insulation, Sicon A (white paint), Carroll #1019 Epoxy base paint and Lockheed Paints 1747 and 10619.

The test equipment consists of an ultra high vacuum system which pumps out a chamber containing the ultraviolet source and samples. Vacuum attainable in the chamber is 10^{-9} TORR. The ultraviolet intensity is equivalent to 6 suns. Means for controlling sample temperature are included.

Type of Program: Applied Research and Development

Material Classification: Miscellaneous Special Purpose Materials

Descriptive Title: Fabrication of Mylar Inflatable Structures

Objective: To evaluate techniques and procedures for constructing Inflatable Antennas utilizing mylar-aluminum-mylar laminates.

Abstract of Results and Conclusions: Leakproof sealing methods, compatible with mylar-aluminum-mylar laminates, are currently under investigation. Various heat sealing techniques are being evaluated with specific emphasis on rate of heating, sealing temperature, and bonding pressure. Representative bonds of several sealing methods have been evaluated in simple tensile tests. These tests have shown that it is possible to seal mylar to itself and to achieve a bond strength essentially as strong as the parent material. Construction of various configurations useful for inflatable antennas leads to problems of sealing along curves where wrinkling of the material is a problem. Special shaping and sealing to avoid such difficulties is also being examined.

Feb 62

EVALUATION OF STRETCHED PLEX 55 FOR AIRPLANE CANOPY APPLICATION

Introduction

Multiaxially stretched Plex 55 is being evaluated at Chance Vought Laboratories to determine its suitability for use in airplane canopies. Static and fatigue tests were performed on elemental specimens of the material and various data comparisons were made.

Since most of the test failures occurred in the plastic through the attachment holes, it is considered that the primary value of the program lies in evaluation of the method of attaching Plex 55 to its retaining structure. Further testing to evaluate other aspects of the materialsis still in progress.

Discussion

The following paragraphs describe the tests which were performed and offer comparisons of the resulting data.

Two different configurations of joints using Plex 55 were compared. One consisted of bolting through the glass with laminated orlon bonded to it; the other employed a bonded butt block. Since the "bolt through" joint proved superior in all respects in the preliminary evaluation, no further work was done on the butt block joint.

Static and fatigue characteristics of the stretched plex were compared with "as cast" material. Stretched plex with four laminates of bonded Orlon edging indicated a static strength improvement of about 8% over "as cast". Fatigue strengths of the two materials were comparable.

Static tests at 170°F revealed a strength reduction of approximately 4% as compared to room temperature tests of the stretched Plex 55.

Attention was given to special methods of preparing the attachment holes in some specimens. Although this prodedure did not result in actually increasing overall fatigue life, scatter was greatly reduced by reducing the number of erratic low cycle failures.

Conclusions

In view of the foregoing, stretched Plex 55 would meet the same service requirements as service proven "as cast" acrylic when certain installation procedures are observed. It is therefore considered structurally acceptable for use as a canopy material.

TR 50-2006 (Corporate Funded)

TITLE: Investigation of New Unconventional Polymerization Techniques and Development of Semi Inorganic Polymers

OBJECTIVE: To investigate by literature search and laboratory experiments:

(1) Unconventional polymerization techniques such as the use of liquid metals, fused salts, and high temperature fluids as polymerization media which could yield high temperature polymers with acceptable processing characteristics.

(2) Polymerization of semi-inorganic polymers with inherent high temperature properties.

DISCUSSION: Work will be directed toward finding a low density low melting, high boiling, non-reactive media suitable for use as a polymerization media. Materials to be considered include hydrocarbon wax (in oxygen free atmosphere), silicone oil, camphor, abitol, and hydrocarbon oil (in oxygen free atmosphere). Some of the possible monomers to be investigated for polymerization in selecting a media are:

(a) Stearylmethacrylate
(b) Ethylacrylate
(c) Laurylmethacrylate
(d) Butylacrylate
(e) Methylmethacrylate
(f) Octyl-Decylmethacrylate

Monomers to be utilized for possible thermal resistant polymers are:

(a) B-Triphenylborazole
(b) B-Trimethylborazole
(c) Hexamethylborazole
(d) Aluminum Phenoxide
(e) Aluminum Oxinate
(f) Aluminum Isopropoxide
(g) P-phenylenediamine
(h) Benzidene
(i) Melamine
(j) Triallyl Isocyanurate

A series of tests such as molecular weight, curing agents, water resistance, fuel resistance, etc., will be used to screen promising polymers.

TR 50-2006 (Continued)

The use of conventional polymerization methods will be utilized should it be determined that a promising polymer can be more easily synthesized in this manner.

RESULTS. The solvent and water resistance of the elastomeric materials resulting from reactions of phosphonitrilic chloride trimer and $CoCl_2$ and $NiCl_2$ in sealed, evacuated glass tubes at 300°C has been determined. It was found that the elastomers swelled in common non-polar solvents and appeared to react with ketones. Both materials were unstable to water; however, the elastomeric material resulting from $(PNCl_2)_n$ and $CoCl_2$ appears to be superior to the material from the $(PNCl_2)_n$ and $NiCl_2$ reaction. It was likewise more stable toward hydrolysis. This leads to the speculation that possibly a $(PNCl_2)_n$ metal halide combination can be found which will yield an elastomeric material stable toward hydrolysis; hence a study of the structure of these polymers may shed light on means of successfully altering the molecule toward obtaining a hydrolytically stable material. In addition a cobaltous chloride liquid polymer has been synthesized and present plans are to study its structure by use of the infra red-spectrometer before the conclusion of the 1962 program.

Unconventional polymerization techniques have been studied using decyl-octyl methacrylate as a monomer in various media. The purpose of these studies has been to determine the effect of various reactive media on polymers of common organic monomers which may possibly yield improved polymers. It is felt that the knowledge gained here may also be applied to inorganic polymerization. In the field of inorganic polymers, research on inorganic synthesis and techniques is particularly lacking as well as studies on polymerization reactions, and bonding.

These studies have resulted in the elimination of several reactive media for various reasons, but certain polyphenyl ethers, silicone fluids and fused metal salts still show promise and will be investigated further.

COMPLETION DATE: December 1963

TITLE: Composite Materials

SPONSOR: Bell Aerosystems Company

CONTRACT: Internal R&D

DURATION: One year

LEVEL OF EFFORT: One man/year

PROGRAM: Analytical and experimental studies are currently underway to develop information on methods of producing optimum configurations of plastic and/or ceramic composites reinforced with filamentary materials. Physical-chemical investigations are being conducted in the rate of the interface between the fine reinforcing filaments and the binder matrix and its influences on the mechanical behavior of model composites.

1. MATERIALS CLASSIFICATION: Transparent Materials

2. TITLE: Transparent Organic & Inorganic Composite for Elevated Temperature Glazings

3. OBJECTIVE:

Due to limitations of plastic glazing materials and interlayers, the use of double wall configurations with monolithic glass and air space thermal barrier appears mandatory for temperature above the 300-350°F range. This program is concerned with the development of a double wall glazing design for use at temperatures in the 500-to 600°F range.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Theoretical temperature gradient calculations have been made for double wall configurations of glass, air space and laminated plastic. These calculations indicate a relatively large air space will be required to keep plastic temperatures below 350°F unless circulating air cooling is used. Tests will be conducted to verify theoretical data and establish design data.

Test apparatus has been fabricated and glazing materials have been received. Testing has been delayed pending receipt of adequate heating equipment. Completion is planned for Sept. 1962. This Company-sponsored work is of limited magnitude, and is being performed by the Columbus Division.

TR 50-1898 (Funded Under the B-58 Contract)

TITLE Evaluation of Vacuum Post-Cure to Improve Weathering Resistance of Windshield Interlayer Material (Type K Silicone)

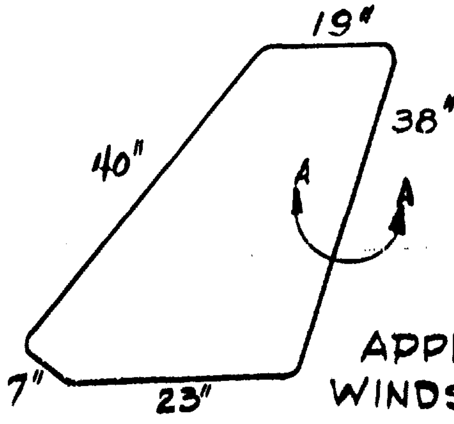
OBJECTIVE: To determine if an extended post-cure under vacuum will improve the weathering resistance of a windshield containing Type K silicone interlayer. The windshield will receive the post-cure after it has been processed by the normal production method used by the manufacturer (Libbey-Owens-Ford).

DISCUSSION: Two production B-58 windshields (General Dynamics Drawing 4B-1132) will be processed as below prior to the accelerated weathering exposure. A third windshield with no post-cure will be used as a control. The windshield will be exposed to accelerated weathering until visual degradation (crazing) of the interlayer has occurred.

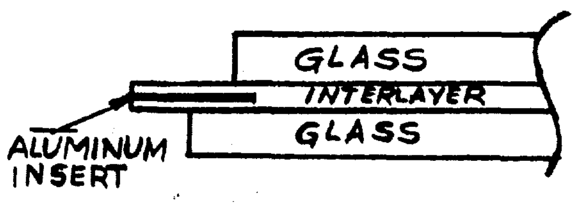
Post-cure Procedure: The windshields will be placed in a container suitable for post-curing the windshields for 48 hours at 300°F while under at least 25" Hg vacuum. Volatiles evolved from the windshields during postcure will be collected and analyzed as to composition.

Accelerated weathering procedure: The two windshields and a control will be exposed in a sealed container which has a soda-lime glass window as one side. The container will be situated so that the windshield inside is exposed to sunlight. Each morning, the container will be filled with a 10% sulphur dioxide and 100% relative humidity atmosphere. Each evening the container shall be purged with fresh air.

Windshield details:



APPROX
WINDSHIELD SIZE & SHAPE



EDGE DETAIL
SECT A-A

RESULTS: This program has been completed and published as FTDM 3035. The report is being submitted under this contract.

FPR-003
ISSUE NO. 2
Nov 63

TR 50-2044 (Funded Under the B-58 Contract)

TITLE. Determine Feasibility of Protecting Type K Silicone Interlayer by Saturating with Selected Non-Deleterious Gases.

OBJECTIVE: To determine the feasibility of saturating cured Type K silicone interlayer with a non-deleterious gas to exclude subsequent entry of deleterious gases.

DISCUSSION. Previous work has shown that exposure to acidic gases, ie sulphur dioxide and nitrogen dioxide, greatly accelerates the deterioration of Type K silicone interlayer. Tests will be accomplished under the program to obtain basic information on the permeability, diffusion, and absorption characteristics of Type K interlayer using various gases. Work will be accomplished to indicate feasibility of being able to "pre saturate" Type K with gases such as Helium, Radon, and Ammonia in order to attempt to exclude the entry of sulphur dioxide and nitrogen dioxide.

RESULTS: The diffusion rate of He and SO_2 through unpigmented, cured and post cured Type K interlayer has been determined using mass spectrograph techniques. The diffusion rate of SO_2 through the post cured Type K is slightly more than that through the cured Type K.

Lap shear type windshield specimens were impregnated using a vacuum technique with diethanolamine, monoethanolamine, tetraisopropyl titanate, gamma-aminopropyltriethoxysilane, and delta-aminobutylmethyldiethoxysilane. These specimens along with a control specimen were subjected to a solarium exposure test. The time-to-first-crack for the control specimen and the specimens impregnated with the first three materials listed above was 6.2 hours. The time-to-first-crack for the specimens impregnated with the last two materials was 16.3 and 29.0 hours respectively.

Additional tests will be conducted to determine the permeability, diffusion, and absorption characteristics of pigmented Type K interlayer and to determine the effects of pre-saturation of Type K with non-deleterious gases.

ESTIMATED COMPLETION DATE: January 1963

NA-61-[illegible]
4-15-62

1. MATERIAL CLASSIFICATION: Textiles

2. TITLE: Evaluation of Glass Fabric

3. OBJECTIVE:

   A comparison of the elevated temperature properties of Owens-Corning's X-37b glass fabric with standard MIL-F-9084 "E" glass fabric having MIL-F-9118 finish was made in the bare state and as laminated with a high temperature resistant pre-impregnated epoxy resin system.

   This limited test program was undertaken to up date information relative to high temperature properties of glass fabric.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

   1. Laminates fabricated with standard "E" glass fabric had higher tensile, flexural and compressive strengths up to 500F. This is attributed to the better nesting or compaction of the "E" fabric.

   2. The bare cloth breaking strength and strength-to-weight ratio for the X-37b glass fabric is highest.

   3. The bare X-37b fabric (with finish removed) is thicker and heavier than the standard "E" fabric.

This work was performed at S&ID in connection with an Air Force Contract.

Index No. 2[illegible]4

6.2.5.1 MISCELLANEOUS STRUCTURES

EXPLORATION AND EVALUATION OF NEW GLASSES IN FIBER FORM

<u>Objective</u>

The prime objective of the program is the examination of the length effect on strength properties of glass fibers based on reported statistical analysis and of the upper limiting strength fibers with the purpose to determine the strongest fiber for particular applications. Further objectives are the evaluation of Solar glasses and the investigation of the short fiber staple effect.

<u>Results and Conclusions</u>

Commercial E glass fibers (Owen-Corning's ECG 150-1/0) were tested in lengths from 1.5 cm to 24 cm. Average strength values ranged from 200,000 to 350,000 psi. It was found that the strength decreased with increasing fiber length. The decrease in strength can be expressed as the mechanical damage coefficient

$$\alpha = \bar{\sigma}/\sigma_0 - \bar{\sigma}$$

as a straight line function of fiber length plotted on log-log paper.

Strength measurements have been made on Owen-Corning's X-994 glass fibers separated from a 204 filament strand treated with 195 finish. Tested to date were lengths of 24 cm, 12 cm, and 6 cm. Evaluation is in progress. Maximum strength values in excess of 500,000 psi have been obtained.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

ELASTOMER; FABRIC; CLOTHING; LINT CONTROL

DESCRIPTIVE TITLE:

Investigation to Determine Advisability of Using Synthetic Fabrics for Coveralls Furnished to Shop Personnel (working where a lint-free condition is desired)

OBJECTIVE:

Investigate characteristics considered relevant such as, lint shedding, susceptibility to electrostatic generation and the possibility of lowering electrostatic generating properties by treating fabrics with commercially available anti-static solutions.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Results of tests indicated that the most desirable fabric was #1600 Blend Dacron treated with Neutrostat "B". Due to the lack of durability of the treating solution, it will be necessary to make applications following each wash. The lint shedding test pointed out that the #1600 Dacron Blend was superior to cotton. New cotton produced four times as much lint as Dacron Blend and used cotton produced about ten times as much lint as the Dacron Blend.

By extending test results so that the shedding of the fabric was produced, the wear life of the fabric was determined. These tests indicated that the wear life of #1600 Dacron Blend was approximately 2-1/2 times that of cotton. Electrostatic showed that #1600 Blend fabric treated with anti-static solution Neutrostat "B" was superior to cotton fabric from the standpoint of static accumulation. Washing tests indicated that many of the anti-static solutions were permanent, so a choice was made on the basis of ease of application and static reduction.

Aston 108 was satisfactory from the standpoint of static reduction, however if proved difficult to apply and would be costly to use commercially. Of the two remaining treatments, solution Neutrostat "A" gave the greatest reduction in static generation.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

FABRIC, COATED, FLUOROCARBON ELASTOMER

DESCRIPTIVE TITLE:

Fluorocarbon Elastomer Coated Fabrics

OBJECTIVE:

To evaluate an Irvington Varnish and Insulator Company Fluorel Coated Dacron Fabric AFD-8.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A fluorel coated "Dacron" fabric was investigated for aircraft balance seal applications. It was found to have excellent chemical and solvent resistance, heat resistance to 250°F and a tensile strength circa 125#/inch. Its low temperature flexibility was not acceptable for balance seal applications.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

FABRIC, SILANE FINISH; REINFORCEMENT, RESIN IMPREGNATED LAMINATE

DESCRIPTIVE TITLE:

Union Carbide and Carbon Corporation A-172 Silane Finish Fabric Impregnated with Polyester Resin

OBJECTIVE:

The purpose of this program was to evaluate A-172 Silane finish fabric for possible use as a reinforcement to be used with polyester resins in the fabrication of structural laminates.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Volan A finish fabric and Garan finish fabric are commonly used as a reinforcement with polyester resins. Volan A finish fabric impregnates faster than Garan finish fabric and the laminate after cure is more transparent than are laminates fabricated using Garan finish fabric. However, the electrical and mechanical properties of laminates fabricated using Garan finish fabric are superior to those obtained using Volan A finish fabric.

Information released by Union Carbide and Coast Mfg. Company concerning A-172 Silane finish fabric, a relatively new fabric finish developed for use with polyester resins, states that laminates fabricated using A-172 Silane finish fabric impregnated quickly and possessed good electrical and mechanical properties after cure.

Some A-172 Silane finish fabric was procured and several laminates were fabricated for test purposes. During layup it was noticed that the laminates impregnated faster than laminates fabricated using Volan or Garan finish fabric.

The A-172 laminates were transparent after cure. The electrical properties were better than those obtained with Volan A finish fabric and equal to those obtained with Garan. The mechanical properties were equal to those obtained with Garan finish fabric. A-172 Silane finish fabric is quite suitable as a reinforcement for polyester resins.

1. MATERIAL CLASSIFICATION: Insulation (Electrical)

2. TITLE: Evaluation of the Behavior of Electrical Potting Compounds at Cryogenic Temperatures.

3. OBJECTIVE:

A moderate effort to investigate several types of electrical potting compounds to determine their suitability for use in potting solid state electronic devices to operate in an environment down to -250°F.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Preliminary evaluation included thermal shock and impact testing of typical polysulfide, polyurethane, room temperature vulcanized silicone and 20% silica filled epoxy potting compounds. Thermal shock test samples consisted of 2-inch diameter by 1-inch long cylinders of the compound containing seven quarter-inch diameter rods embedded at various locations. The polyurethane rubber compound was the only type which withstood an R.T. to -250°F thermal shock test. Impact strength at -250°F of the polyurethane compound was 80 inch-pounds per inch of notch. Tensile strength and tear strength of this compound was as follows:

Condition	Tensile Strength	Tear Strength
R. T.	425 psi	54 lbs/inch
-250°F	9000 psi	-
At R.T. after five cycles from R.T. to -320°F	425 psi	55 lbs/inch

This work is performed by Rocketdyne under NASA contract and is 50% complete.

MATERIALS RESEARCH PROJECT SUMMARY

GDA

Period: 1 March 1961 to 1 Septembe- 1961

Material Classification: Insulation Materials

Materials: Mylar

Title: A Study of Insulation Materials for the Centaur Intermediate Bulkhead.

Project No. AWO 792-1001

Objectives: The purpose of the work conducted was to develop a thermal insulation system for use on the intermediate bulkhead of Centaur vehicles in order to reduce excessive LH_2 boil-off.

Results and Conclusions: Of all materials tested for filling the faying surface cavity, the most promising was a Mylar laminate (layers of Mylar bonded with polyester adhesive). This laminate when bonded to 301 CRES with polyester film adhesive withstood approximately nine (9) lbs./in. peel at -423°F. All other materials tested showed very poor adhesion to steel at -423°F and excessive cracking.

Satisfactory insulation bags can be prepared from the following combinations:

(1) Seam welded steel or aluminum

(2) GT-100 sealed Mylar, aluminum or steel foil envelopes.

These systems can be used with any insulating materials such as plastic foam, fiber glass, powders, etc. The systems can also be fabricated to hold a 25 micron vacuum.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

21 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; AVCOAT (EPOXY-POLYAMIDE); HEAT SHIELD

DESCRIPTIVE TITLE:

External Insulation Evaluation - Minuteman

OBJECTIVE:

To determine the applicability of AVCOAT ablative material as a protective shield for Minuteman external surfaces.

ABSTRACT OF RESULTS AND CONCLUSIONS:

AVCOAT was tested in comparison with other plastic materials that ablate at low temperatures (350°F to 700°F). The test program included the determination of thermal properties and processing characteristics. The ablative performance was determined under exposure to "plasma jet" and rocket exhaust gases. Minuteman conditions were simulated. AVCOAT compared favorably with the other materials in respect to thermal and ablative properties. It is more easily applied by spraying than the other materials tested.

Ablation Temperature	650°F
*Heat of Ablation	1100 BTU/lb

Details are reported in BAC document D2-5202-1 (Conf.)

*Under Minuteman boost cycle conditions.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; PLEXIGLASS 7421; HEAT SHIELD

DESCRIPTIVE TITLE:

External Insulation Evaluation - Minuteman

OBJECTIVE:

To determine the applicability of material as a protective shield for Minuteman external surfaces.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Plexiglass 7421 in sheet form was tested in comparison with other plastic materials that ablate at low temperatures (350°F to 700°F). The test program included the determination of thermal properties and processing characteristics. The ablative performance was determined under exposure to "plasma jet" and rocket exhaust gases. Minuteman conditions were simulated. Plexiglass 7421 rated near the top of the list of materials in respect to thermal and ablative properties. Bonding of sheet material to complex shapes and irregular surfaces presents processing problems. Consideration is being given to the developing of a sprayable acrylic material.

Ablation Temperature	470°F
*Heat of Ablation	1400 BTU/lb

Details are reported in BAC Document D2-5202-1 (Conf.)

*Under Minuteman boost cycle conditions.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 J[illegible]n 6[illegible]

MATERIAL CLASSIFICATION:

THERMAL INSULATION; HIGH TEMPERATURE; EVALUATION

DESCRIPTIVE TITLE:

High Temperature Insulation Materials

OBJECTIVE:

Provide property data on available high temperature insulation materials required for use in detailed thermal and stress analysis.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A test report, number T2-1898, "High Temperature Insulation Screening Tests", has been released. Maximum high temperature capability and volume shrinkage characteristics of seven different commercial insulation materials varying in product form and density were investigated, and are reported. The manufacturer and the trade name of the materials tested in this program are:

A. Carborundum Company

- (a) Fiberfrax Paper 970-FH
- (b) Fiberfrax Blanket XSW
- (c) Fiberfrax Board
- (d) Fiberfrax Block F-20T

B. Johns-Manville Company

- (a) Thermoflex 6, 12 and 24 lb/ft^3 densities
- (b) Min-K
- (c) Micro Quartz Fibers - (Q-Felt)

C. Babcok and Wilcox Company

- (a) Kaowool

D. H. I. Thompson Fiber Glass Company

- (a) Refrasil B-100-1

E. Creative Engineering

- (a) Tempsheet 1000

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

THERMAL, INSULATION MATERIAL, MINUTEMAN BASE AREA; EVALUATION OF

DESCRIPTIVE TITLE:

Minuteman - Base Area Insulation Program

OBJECTIVE:

To evaluate and obtain data on the various insulation materials for use in the base areas of Minuteman.

ABSTRACT OF RESULTS AND CONCLUSIONS:

D2-5202-1, Addendum F, documents results of the Minuteman - Base Area Insulation Program. Materials tested were:

Type or Description	Manufacturer	Designation
Epoxy-polymide	Avco Manufacturing Co.	Avcoat I
Buna-N rubber compound	Goodyear Tire & Rubber Co.	M850A
Modified Buna-N rubber compound	Stoner Rubber Company	SMR 7-12
Neoprene-cork	Boeing	BMS 1-39
Phenolic impregnated glass fabric	Coast Manufacturing Co.	F120-11-181
Silicone sealant	Products Research Co.	PR-1910
Silicone sealant	General Electric Co.	RTV 88
Silicone sealant - reinforced	Raybestos Manhattan	RL 864
Silicone rubber	General Electric Co.	SE-555
	Emerson Engineering Co.	Thermolag

2-5546-0-9

Index No. 204

The following information and data are included:

(1) A description of materials and material processing techniques.

(2) Physical and mechanical properties, including the effects of temperature and aging on these properties.

(3) Thermal properties.

(4) Combustion characteristics.

(5) Results of comparative tests on the insulations directed at evaluating over-all insulation efficiency.

(6) An analysis of results and recommendations for insulation applications in the missile base area.

1. <u>MATERIAL CLASSIFICATION</u>: Elastomers

2. <u>TITLE</u>: Effect of MIL-H-5606 Hydraulic Fluid on Elastomer Properties

3. <u>OBJECTIVE</u>:

To evaluate the change of properties of four elastomers during a three-year immersion in MIL-H-5606 hydraulic fluid. These data will determine the suitability of these elastomers for use a O-Ring Materials where a service life of three years is contemplated. This was a limited program with regard to actual time expended to evaluate properties.

4. <u>ABSTRACT OF RESULTS OR CONCLUSIONS</u>:

The following data are average values of two samples of each elastomer:

LS-53 (Fluoro-silicone)

	Value or Change of Property at end of				
	6 mo.	12 mo.	18 mo.	24 mo.	30 mo.
Specific Gravity Decrease	0.029	[illegible]	0.20	0.022	0.025
Volume Increase, %	4.26	3.19	4.42	4.02	5.01
Tensile Strength, psi	1698	728	524	479	603
Ultimate Elongation, %	275	150	150	113	125

Neoprene W

	Value or Change of Property at end of				
	6 mo.	12 mo.	18 mo.	24 mo.	20 mo.
Specific Gravity Decrease	0.095	0.077	0.086	0.094	0.096
Volume Increase, %	18.98	14.83	18.96	18.66	19.21
Tensile Strength, psi	1850	1591	952	1418	1397
Ultimate Elongation, %	238	184	198	123	128

Buna N

	Value or Change of Property at end of				
	6 mo.	12 mo.	18 mo.	24 mo.	20 mo.
Specific Gravity Decrease	0.021	0.022	0.013	0.010	0.012
Volume Increase, %	0.46	1.31	-0.84	-1.20	-0.79
Tensile Strength, psi	3440	1811	1568	1643	1290
Ultimate Elongation, %	257	268	245	119	133

Viton A (Vinylidene fluoride and hexafluoropropylene copolymer)

	Value or change of property at end of				
	6 mo.	12 mo.	18 mo.	24 mo.	30 mo.
Specific Gravity Decrease	0.019	0.041	0.080	0.024	0.026
Volume Increase, %	1.50	2.75	3.25	2.33	2.32
Tensile Strength, psi	2645	1351*	1464	1543	1215
Ultimate Elongation, %	238	156*	169	77	114

* Value from one sample only.

A final evaluation (the 36th month) remains to be made for completion of this project. The work is being conducted at Autonetics under Air Force sponsorship.

1. MATERIAL CLASSIFICATION: Elastomers

2. TITLE: Physical and Electrical Properties of Molding Compounds

3. OBJECTIVES:

To determine, in an extensive program, the tensile and tear strength, percent elongation, the 300 F aging values of the above properties, the hardness, specific gravity, flammability, ozone resistance, dielectric constant, and dissipation factor of elastomeric molding compounds. These properties will be used for a preliminary screening of materials to be evaluated for cable jacketing in areas of high thermal environments

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The following materials have been evaluated:

Material	Color	Type	Source
SMR 7-12	Tan	Silicone modified Buna N rubber molding compound	Stoner Rubber Co.
6029-1	White	Neoprene rubber molding compound	Stoner Rubber Co.
650-B-750	White	" " " "	Kirkhill Rubber Co.
SE 555	Red	Silicone rubber molding compound	General Electric
SE 555	White	" " " "	General Electric
XE 505	Red	" " " "	General Electric
SR 7575	Red	" " " "	Sierra Rubber Co.
DC 916	Red	" " " "	Dow Corning Corp.
DC S-2048	White	" " " "	Dow Corning Corp.

The physical properties determined for these materials are:

Material	Shore A Hardness	Specific Gravity	Flammability (Seconds to extinguish)
SMR 7-12	78	1.53	48
6029-1	65	1.57	
650-B-750	60	1.68	0
SE 555 Red	53	1.20	57
SE 555 White	50	1.20	68
XE 505	50	1.22	53
SR 7575	60	1.26	89
DC 916	45	1.12	65
DC S-2048	60	1.33	43

Index No. 296

Evaluation of the effect of 300 F aging on the tensile and tear strength and percent elongation gave the following results:

Material	Aging Temp. (°F)	Hours of Aging Temperature											
		*Tensile Strength				Elongation (%)				**Tear Strength			
		0	50	100	200	0	50	100	200	0	50	100	200
SMR 7-12	263	1710	3325	3550	2400	650	50	50	50	567	417	-	-
6029-1	263	1540	623	-	-	465	25	-	-	383	79	-	-
650-B-750	263	466	1157	732	-	150	275	25	-	258	300	100	-
SE 555 Red	300	1430	1400	1275	1175	450	450	325	325	217	208	205	208
SE 555 White	300	1892	2141	1676	1846	400	400	325	325	246	234	215	225
SR 7575	300	2210	2000	2100	1850	400	350	350	325	259	244	244	260
DC 916	300	1370	1500	1250	1450	275	50	50	50	214	198	215	200
DC S-2048	300	898	866	930	460	200	200	185	150	150	160	150	75
XE 505	300	1525	1510	1510	1500	700	725	725	750	249	242	258	255

The dielectric strengths and dissipation factors were determined to be:

Material	Dielectric Constant		Dissipation Factor	
	100 cycles/sec	10,000 cycles/sec	100 cycles/sec	10,000 cycles/sec
SMR 7-12	12.81	11.54	0.1885	0.1501
6029-1	7.90	7.26	0.0542	0.0258
650-B-750	10.35	8.69	0.2078	0.0406
SE 555 Red	3.05	3.00	0.0066	0.0041
SE 555 White	3.09	3.04	0.0049	0.0054
XE 505	3.23	3.17	0.0063	0.0058
SR 7575	3.15	3.09	0.045	0.0037
DC 916	3.27	3.14	0.0044	0.0027
DC S-2048	3.30	3.15	0.0152	0.0083

This work is being performed under Autonetics sponsorship and will be completed 10 November 1961

1. **MATERIAL CLASSIFICATION: Elastomers**

2. **TITLE: Physical and Electrical Properties of Two-Component Room Temperature Curing Castable Silicone and Polyurethane Elastomers.**

3. **OBJECTIVE:**

An extensive program has been undertaken to determine the tensile and tear strength, percent elongation, effect of 300 F aging on the above properties, specific gravity, bond strength, flammability, dielectric constant, and dissipation factor of castable elastomeric materials. These values will serve as a basis for selection of materials having potential application for thermal insulation of metal substrates subjected to a high thermal environment.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The following materials have been evaluated:

Compound Number	Color	Type	Source
RTV-60	Red	Two-component room temp. curing castable silicone elastomer	General Electric
RTV-X77	White	Two-component room temp. curing castable thixotropic silicone elastomer	General Electric
RTV-88	Red	" " "	General Electric
RTV-11	White Translucent	Two-component room temp. curing castable silicone elastomer	General Electric
RTV-558	Red	" " "	Amphenol-Borg
PR-1520	White	Two-component room temp. curing castable polyurethane elastomer	Products Research

The physical properties determined for these materials are as follows:

Material	Shore A Hardness	Cured Specific Gravity	Abrasion Resistance (G/1000 RPM)	Peel Strength (lbs/in)	Flammability (seconds to extinguish)
RTV-60	57	1.50	0.0965	5.5[1]	45
RTV-X77	45	1.3[illegible]		14.0[1]	69
RTV-88	65	1.53			48
RTV-11	45	1.19			71
RTV-558	30	1.46	0.1037	2.2[1]	40
PR-1520	52	1.17		20.0[2]	108

[1]Alclad aluminum primed with SS-4004 primer (General Electric)
[2]Alclad aluminum primed with PR-611 primer (Products Research Co.)

Aging at 300 F had the following effect on the tensile and tear strength and percent elongation:

Material	Aging Temp. (°F)	Tensile Strength (psi) 0	50	100	200	Elongation (%) 0	50	100	200	Tear Resist. (lbs/in) 0	50	100	200
		Hours at Aging Temperature											
RTV-60	300	625	625	675	625	125	125	150	125	109	104	120	106
RTV-X77	300	211	320	492	278	110	150	117	110	54	58	59	43
RTV-88	300	926	519	496	296	75	75	75	80	87	46	31	26
RTV-11	300	223	224	219	233	90	115	115	100	40	19	59	31
RTV-558	300	300	550	525	450	150	200	200	175	54	72	84	84
PR-1520	263	361	622	562	435	250	175	1170	160	99	94	96	74

The dielectric constant and dissipation factor of the materials were found to be:

Material	Dielectric Constant 100 cps	Dielectric Constant 10,000 cps	Dissipation Factor 100 cps	Dissipation Factor 10,000 cps
RTV-60	4.03	3.76	0.0230	0.0161
RTV-X77	4.03	3.73	0.0207	0.0250
RTV-88	4.09	3.57	0.0376	0.0313
RTV-11	3.31	3.20	0.0156	0.0061
RTV-558	3.81	3.69	0.0213	0.0077
PR-1520	6.64	5.79	0.0319	0.0576

This work is sponsored by Autonetics and will be completed 10 November 1961.

1. MATERIAL CLASSIFICATION: Elastomers

2. TITLE: Analysis of the effects of in-service aging on the properties of rocket propulsion system soft goods.

3. OBJECTIVE: An extensive effort to evaluate the effect of in-service aging on propulsion system soft goods including static and dynamic O-rings, lip seals, gaskets, diaphragms, and similar parts to establish whether or not the service life of the propulsion system can be increased from twenty-four months to thirty-six months or longer.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

An evaluation of the soft goods obtained from five Thor propulsion systems which have been operational for 23, 30, and 33 months has been conducted. Following component testing, the soft goods are removed from the components, inspected, the dimensions measured, and then tested for hardness and tensile strength. Additional tests have been performed on selected soft goods to determine the aging sensitivity of other properties which might be affected by aging. These properties included tensile modulus, compressive modulus and compression set. The deterioration of these properties would appear to be more closely related to unsatisfactory performance of components in an engine system than those originally included in this program. All property values obtained are compared with values obtained from identical, unused parts taken from current stock. Typical results are as follows:

Part	Location	CONTROL PARTS Tensile Str. Psi	CONTROL PARTS 100% Mod. Psi	ENGINE PARTS Tensile Str. Psi	ENGINE PARTS 100% Mod. Psi
AN 6227B-12	Gas Generator Actuator Assy	1800	370	1550	480
AN 6290-12	Fuel Start Tank Valve Assy	1800	900	1700	1270
MS 29513-24	Pneu. System Solenoid Valve	1370	340	1200	430
MS 29513-241	Gas Generator Injector	1430	250	990	360

The soft goods, after a maximum of thirty-three months of service in Thor engines, are in satisfactory, serviceable condition. In relating the results of these analyses to component tests, there have been no indications of malfunction as a result of material degradation.

Indications are that the tensile modulus property is sensitive to aging (increasing with age) and the testing of this property will be included in all future aging study programs.

The basic aging study program conducted by Rocketdyne under USAF contract has been completed. The evaluation program has been extended on a project-to-project basis to include soft goods from engine systems of longer service life than previously tested.

MA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Elastomers

2. TITLE: Physical Properties of Several Elastomers

3. OBJECTIVE: A limited evaluation was conducted to determine the hardness, specific gravity, tensile strength, ultimate percent elongation, tear strength, and and thermal aging resistance at 167 F of several molded and extruded elastomers.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Test Results After Initial Cure (Molded)

Material	Source	Tear (psi)	Tensile (psi)	Ultimate Elongation (Percent)	Hardness Shore A	Specific Gravity
#601 Polyurethane	Ace Rubber	440	3170	575	65	1.30
#3026 Hypalon	Ace Rubber	275	1900	400	60	1.27
#339 Neoprene	Ace Rubber	321	1800	350	70	1.45
0360-B-751 Neoprene	Kirkhill Rubber	226	1860	540	60	1.46
60-F-55 Neoprene	Extruded Products	247	1627	350	60	1.30
8013-2 Chlorobutyl	Stoner Rubber Co.	192	1243	475	55	1.15

Test Results After Heat Aging (Molded)

Material	Source	Tear (psi)	Tensile (psi)	Ultimate Elongation (Percent)	Hardness Shore A	Specific Gravity
#601 Polyurethane	Ace Rubber	490	3180	575	65	1.30
#3026 Hypalon	Ace Rubber	324	2218	300	65	1.26
#339 Neoprene	Ace Rubber	305	1874	275	80	1.44

Test Results After Initial Cure (Extruded)

Material	Source	Tear (psi)	Tensile (psi)	Ultimate Elongation (Percent)	Hardness Shore A	Specific Gravity
0360-B-751 Neoprene	Kirkhill Rubber	225	1700	500	60	1.46
60-B-55 Neoprene	Extruded Products	211	1452	325	60	1.30
8013-2 Chlorobutyl	Stoner Rubber	138	881	425	55	1.15

This work was sponsored by Autonetics

1. MATERIAL CLASSIFICATION: Epoxy Fiberglass Laminates

2. TITLE: Dielectric Constant, Volume Resistivity and Dissipation Factor Tests on Epoxy Glass Laminates

3. OBJECTIVE:

A limited evaluation was conducted to determine the dielectric constant, volume resistivity, and dissipation factor of several epoxy glass laminates, as received and after being immersed in water for 24 hours. Dissipation factor and dielectric constant were determined at a frequency of 10 kc. Volume resistivity was measured at a potential of 500 volts.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The results obtained on six different epoxy fiberglass laminates are presented in the accompanying chart.

This work was sponsored by Autonetics.

Material and Type	Sample No.	As Received: Dielectric Constant	As Received: Dissipation Factor	As Received: Volume Resistivity, ohm-cm	After 24 Hour Immersion in Water: Dielectric Constant	After 24 Hour Immersion in Water: Dissipation Factor	After 24 Hour Immersion in Water: Volume Resistivity, ohm-cm	After 24 Hour Immersion in Water: Change in Dielectric Constant %
Minn.	1	4.81	.0142	6.2×10^{13}	4.86	.0158	1.6×10^{13}	1.04
Mining,	2	4.71	.0148	5.4×10^{13}	4.85	.0191	2.8×10^{13}	2.97
Type I, GEB	3	4.79	.0143	7.2×10^{13}	4.91	.0218	2.7×10^{12}	2.50
Minn.	4	4.63	.0143	3.9×10^{13}	4.82	.0266	1.5×10^{13}	4.10
Mining,	5	4.41	.0160	3.9×10^{13}	4.62	.0173	3.1×10^{12}	4.76
Type II, GEB	6	4.62	.0173	3.8×10^{13}	4.78	.0221	3.9×10^{12}	3.46
G.E.,	7	4.52	.0102	4.3×10^{13}	4.61	.0129	1.7×10^{12}	1.94
GEE	8	4.65	.0091	4.4×10^{13}	4.84	.0121	6.3×10^{11}	4.08
	9	4.57	.0105	4.3×10^{13}	4.66	.0142	7.9×10^{12}	1.96
Taylor,	10	4.68	.0144	1.5×10^{13}	4.82	.0240	8.5×10^{12}	2.99
Type I,	11	4.72	.0130	2.7×10^{13}	4.80	.0200	1.6×10^{13}	1.71
GEB	12	4.72	.0137	2.7×10^{13}	4.88	.0215	4.6×10^{12}	3.39
Taylor,	13	4.57	.0145	1.2×10^{13}	4.68	.0220	1.2×10^{12}	2.40
Type II,	14	4.57	.0143	4.1×10^{13}	4.61	.0239	8.2×10^{11}	0.87
GEB	15	4.53	.0131	8.2×10^{12}	4.66	.0277	1.6×10^{13}	2.86
Taylor,	16	4.55	.0099	1.1×10^{13}	4.63	.0112	8.2×10^{11}	1.75
Type II,	17	4.65	.0094	4.0×10^{13}	4.71	.0120	5.7×10^{12}	1.29
GEE	18	4.64	.0101	1.3×10^{13}	4.84	.0113	1.2×10^{12}	4.31

VOUGHT AERONAUTICS

DEVELOPMENT AND EVALUATION OF A HIGH TEMPERATURE PHOTOELASTIC COATING

Purpose

The purpose of this program was the development and evaluation of a photoelastic coating that could be used for elevated temperature structural testing.

Procedure

The program consisted of the following steps:

1. A number of plastic manufacturers and compounders were asked for information about any of their materials having those properties deemed desirable for a high temperature photoelastic coating.

2. Those materials that showed the most promise were calibrated to determine which one had the best optical properties. The most promising material appeared to be DER 332, catalyzed with Furane 9425.

3. A number of specimens were cast, with various percentages of catalyst and with various post-cure cycles to determine the optimum preparation procedure.

4. The material was tested to determine Youngs modulus vs temperature, thermal coefficient of expansion vs temperature, optical creep properties, and variation in optical sensitivity with time.

5. Testing is now being done with larger specimens to determine the characteristics of the material when applied to full-scale tests.

Conclusions

The coating developed by Chance Vought yields good results up to a temperature of 400°F, and with more refined application techniques, it would probably perform well for very short periods of time in the range of 400°F to 500°F.

VOUGHT AERONAUTICS

Oct 61

EVALUATION OF SYSTEMS FOR EROSION PROTECTION

INTRODUCTION

This report summarizes the results of a test program which was conducted in an effort to devise a satisfactory erosion resistant protective system to protect airframe areas which are exposed to rocket blasts or similar environmental conditions.

OBJECT

To determine by sandblasting if any of 44 different systems will provide adequate protection to the aforementioned blast areas.

DESCRIPTION OF TESTS

1. Neoprene rubber 0.064 inch thick, 40 durometer and 2 sheets neoprene rubber 0.032 inch thick, 60 durometer were used as controls throughout this test.

2. This test consisted of seven parts, in which several systems were investigated in each part. The leading systems in each part along with the neoprene rubber controls were compared to each other and the best ones were chosen.

3. Since the sand blasting was done at different times on different machines, the sand in the machine was different each time a different part was run, but was uniform during the testing of any one part.

4. The nozzle of the sand blast machine was kept at a constant four inches from the samples and a pressure of 100 psi was used.

5. A complete breakthrough of the protective layer (i.e., to the base metal) constituted a failure.

6. The thickness of the organic samples was determined by making them approximately comparable by weight to the metal specimens.

CONCLUSIONS

1. Neoprene rubber 0.032" plus 0.010" mylar plus 0.032" neoprene rubber plus 0.010" mylar proved to be the best coating system of all of the forty-four systems investigated.

2. Measurements taken on rubber and metal coatings showed that the rubber had better erosion resistant properties than the metal.

3. A limited investigation for an adhesive for bonding rubber to metal and rubber to mylar showed that the EC-847 adhesive was best.

REFERENCE

Chance Vought SLTR 61-53430-122 dated 14 August 1961

LAP SHEAR BOND STRENGTHS OF SPECIFICATION CVA 8-405 TYPES III AND IV RESINS, MODIFIED

INTRODUCTION

A recent shipment of Epon 828 resin did not meet newly established requirements of 800 psi shear bond strength. This test is designated to determine if the specification requirements are realistic. Because curing agent CL is not available, curing agent Z will be substituted.

OBJECT

The object of this test is to determine the lap shear bond strength of Epon 828 resin using Diethylenetriamine (DTA) and Epon curing agent Z.

DESCRIPTION OF TESTS

Two fiberglass panels measuring 12 by 18 inches were bonded to furnish materials for making test specimens which were made in accordance with the following procedures.

1. Thirty-six pieces 4.5 inches by 1 inch were cut from the aforementioned fiberglass panels.

2. One ply of cloth was peeled from each part to improve the bonding surface.

3. Three specimens were assembled using Epon 828 catalyzed with diethylenetriamine and cured for 7 days.

4. Three specimens were assembled using Epon 828 catalyzed with curing agent Z and cured for 7 days plus a post cure of 350°F for 2 hours.

5. Three specimens were assembled using Epon 828 catalyzed with diethylenetriamine and cured at 200°F for 135 minutes.

6. Three specimens were assembled using Epon 828 catalyzed with diethylenetriamine and cured for 24 hours at 72°F.

7. Three specimens were assembled using Epon 828 catalyzed with curing agent Z and cured 24 hours at 72°F plus 2 hours at 350°F.

8. Three specimens were assembled using Epon 828 catalyzed with curing agent Z and cured for 135 minutes at 200°F plus 120 minutes at 350°F.

9. A light weight was placed on all specimens during cure.

10. All specimens were tested at room temperature to determine the tensile shear strength.

VOUGHT AERONAUTICS

CONCLUSIONS

1. Epon 828 resin catalyzed with diethylenetriamine will meet shear strength requirments when cured 135 minutes at 200°F.

2. Epon 828 resin catalyzed with Epon curing agent Z will meet strength requirements when cured 7 days at room temperature and post cured 120 minutes at 350°F.

3. Epon 828 resin catalyzed with curing agent Z yielded a wide range of values above and below the requirments when cured at 200°F with a 350°F post cure. This was probably caused by the extreme flow of this material at the high initial curing temperature.

4. Epon 828 resin catalyzed with diethylenetriamine did not produce satisfactory shear strengths when cured at room temperature.

REFERENCE

Chance Vought SLTR 61-53430-192 dated 25 May 1961

VOUGHT AERONAUTICS

COMPOSITE ELASTOMER-METAL O-RING SEALS

INTRODUCTION

The work covered by this report is a continuation of the investigation of composite elastomer-metal O-ring seals initiated under Contract No. AF 33(616)-6182. The earlier work resulted in the development of a technique for embedding a metal spring concentrically in an elastomer O-ring of one size corresponding to the AN 6227-28 O-ring. This approach was attempted in order to improve the physical and mechanical properties of conventional elastomeric O-rings. Evaluation was made for effectiveness without the use of anti-extrusion devices and suitability for static and dynamic applications.

The objective of this contract was to further evaluate composite elastomer-metal O-ring seals by conducting dynamic cycling tests and performing related investigations of spring finishes and adhesives to bond the elastomer to the spring core. As in the earlier work the test conditions were to include -65°F to 600°F, 0 to 4000 psi and reciprocating cycling rates up to 35 cpm with 1 to 5 inches stroke. If satisfactory results were obtained from the dynamic cycling tests, further tests under pneumatic, vacuum, irradiation and simulated long term storage conditions would be performed.

OBJECT

The object of this study was to further develop and test composite elastomer-metal O-ring seals which could provide an elastomer O-ring seal with improved physical properties.

DESCRIPTION OF TESTS

Material selection was based on the results of standard tensile strength tests of the elastomer following exposure to the environmental conditions for which the O-rings were intended. Lap shear tests were conducted to evaluate the adhesives intended for use in bonding the spring core to the elastomer O-ring. Finally, composite elastomer-metal O-rings and conventional O-rings were exposed to dynamic cycling conditions with and without back-up rings at temperatures from room temperature to 500°F.

CONCLUSIONS

Composite seals showed a high rejection rate due to the spring core shifting within the elastomer.

Dynamic cycling without back-up rings gave unsatisfactory results when used as piston seals at 275 and 400°F in a 4000 psi hydraulic system, although at room temperature the composite O-ring seal showed a definite superiority over the conventional non-cored O-ring seal.

The degradation of elastomer properties at elevated temperatures precludes the use of composite elastomer-metal O-ring seals without back-up rings in high temperature dynamic sealing applications.

It is apparent that the potential advantages of the composite elastomer-metal O-ring for high temperature applications can only be realized by the development of a seal materials which retains its physical properties such that the spring core can perform its intended function.

REFERENCE

WADC Technical Report 59-749 Part II dated June 1961, (Final Report under Contract AF 33(616)-7079).

TR 50-1371 (Funded Under the B-58 Contract)

TITLE: Material - Prepare Catalyst for Silicone Leading Edge Sealant

OBJECTIVE: To develop a paste type catalyst for use with Dow Corning QC-2-0046 silicone sealant.

DISCUSSION: The purpose of this test program is to investigate possible liquid carriers which might be used in the development of a suitable paste type catalyst for Dow Corning QC-2-0046 silicone leading edge sealant. The Dow Corning sealant is a one part material which cures when exposed to air. However, when used in thick sections, it does not cure satisfactorily. General Dynamics/Fort Worth developed a powder type catalyst, CS-48, to facilitate the curing of QC-2-0046. Because it is a powder, CS-48 catalyst is difficult to mix with the sealant.

Several liquid carriers will be selected for the investigation. Any of the carriers which prove to be compatible with CS-48, will be further investigated to determine if the resultant paste catalyst is suitable for use with QC-2-0046 sealant.

Compression set and hardness, after exposure to 180°F, 220°F and 260°F, will be measured. Also, any tendency of the cured sealant to sponge at 260°F and a simulated altitude of 50,000 feet will be investigated.

Results: Eight liquid carriers have been investigated and two were found to be satisfactory. These two, DC-200 silicone compound and uncatalyzed XF-1-0042 silicone polymer were used to formulate two paste type catalyst systems which were found to be suitable for curing QC-2-0046 silicone sealant.

ESTIMATED COMPLETION DATE: The test was completed in July 1962 and report FTDM No. 3065 has been prepared and will be released soon.

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: Adhesive Evaluation - Ground Based Non-Housed Antennas

3. OBJECTIVE:

To investigate the durability of selected adhesive systems by exposing bonded specimens to exterior weathering in various climates, comparisons will be made to accelerated laboratory exposures.

4. ABSTRACT OF RESULTS OR CONCLUSIONS

No work was done since the last reporting period, because of a hold-up of bonding tools for fabricating test panels. The new tools will be integrally heated and will duplicate manufacturing techniques employed for bonding production size panels. The test panels exposed to the elements will then be more representative of production panels.

This limited magnitude work is Company-sponsored, with completion anticipated in October 1964, by the Columbus Division.

NA-61-1049-1
11-1-61

1. MATERIAL CLASSIFICATION: Adhesives and Metallic Composites

2. TITLE: Effect of Increased Tape Weight on HT-424 Bond Strength; Investigation of

3. OBJECTIVE: To determine the effect of HT-424 tape weights varying from .135 to .30 lbs/sq. ft. on aluminum honeycomb core-to-face bond strength after short time exposure to temperatures ranging from ambient to 350F.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Test results are summarized in Figures I through III. Strength versus tape weight curves were essentially linear for flexural shear and flatwise tension tests. Peel strengths increased similarly for tape weights up to .25 lbs/sq. ft. after which a decrease was noted due to foaming and slumping of the adhesive mass. This effect caused a wide variation in peel strength values; facing sheets positioned on the top of the test specimen during the cure cycle yielded significantly lower results than those positioned on the lower surface due to flow of the adhesive into the honeycomb core cells and away from the bond line. In general, an adhesive tape weight of .19-.21 lbs/sq. ft. appears optimum for highly stressed honeycomb sandwich structures.

This work was performed under Bureau of Naval Weapons sponsorship by the Columbus Division under a limited program.

Figure 1

FLEXURAL SHEAR STRENGTH VS ADHESIVE TAPE WEIGHT HT-424 ADHESIVE

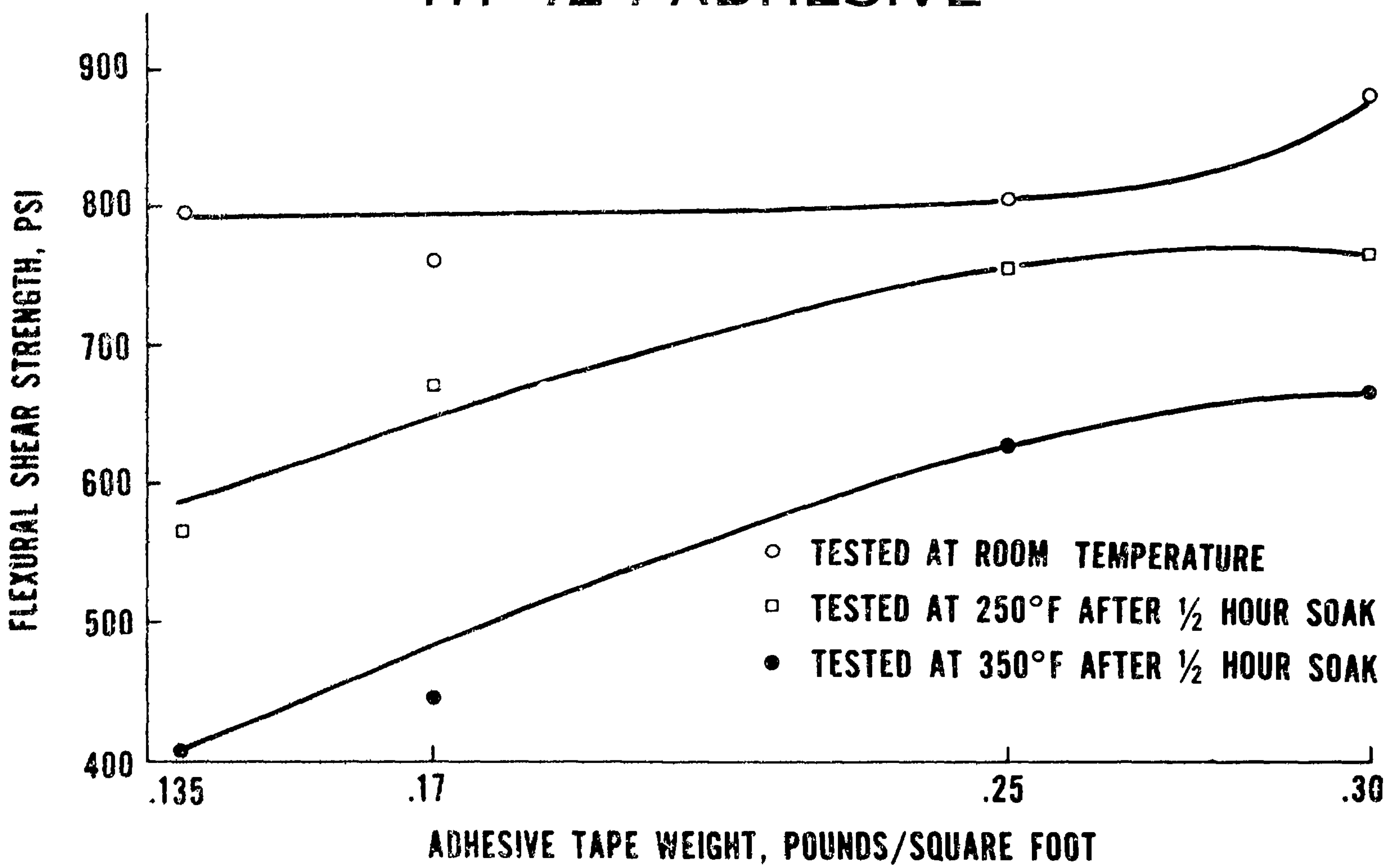


Figure 8

FLATWISE TENSION STRENGTH
VS ADHESIVE TAPE WEIGHT
HT-424 ADHESIVE

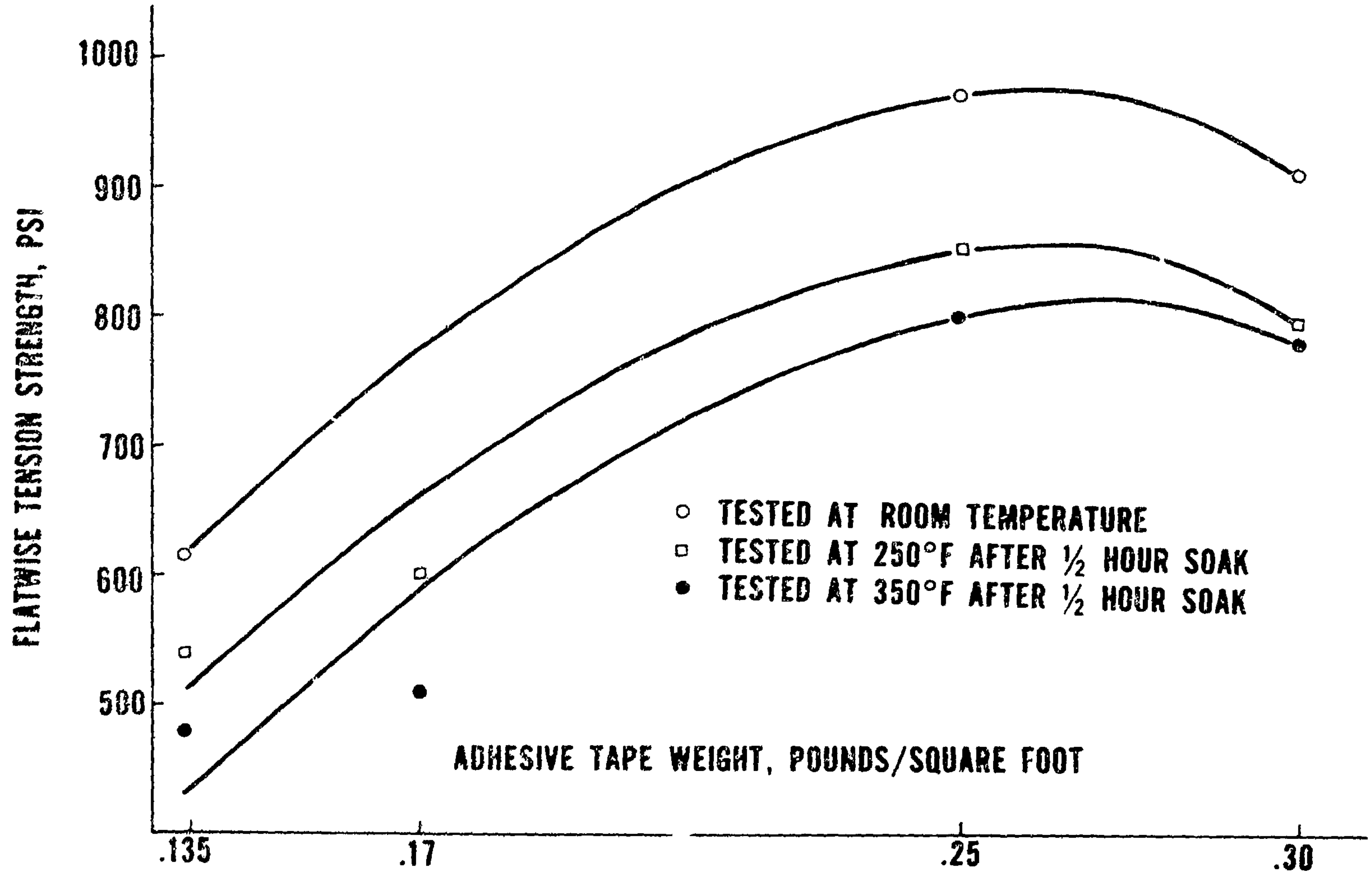
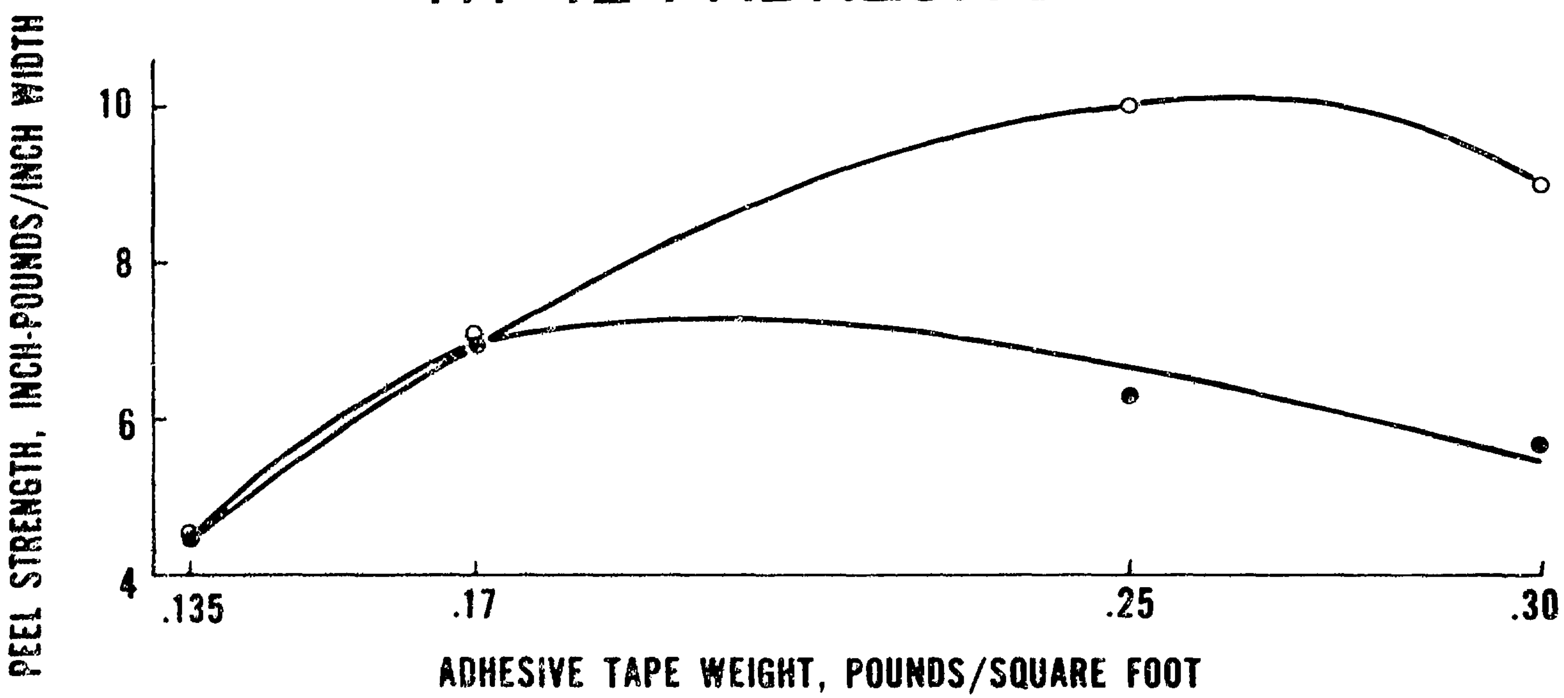


Figure 3

PEEL STRENGTH VS ADHESIVE TAPE WEIGHT

HT-424 ADHESIVE



● FACING LOCATED ON TOP OF SPECIMEN DURING CURE CYCLE

○ FACING LOCATED ON BOTTOM OF SPECIMEN DURING CURE CYCLE

ALL TESTS CONDUCTED AT ROOM TEMPERATURE

MA-61-1049-1
11-1-61

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: Determination of Allowable Shear Strengths for High Temperature Organic Adhesives for Bonded Repairs

3. OBJECTIVE:

Determination of strength properties of high temperature adhesives, particularly Narmco's Metlbond 316, is being conducted in order to establish design allowables. The effect of heat exposures of 200F, 400F, 450F, and 500F for 250 hours on the shear strength of bonded specimens is being determined. In addition, the stress-rupture behavior for 250 hour (minimum) at the same temperatures is being investigated under this extensive program.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

(a) The lap shear strength of the Narmco Metlbond 316 has been determined on .010 PH15-7Mo sheet as follows:

Test Temp.	As Fabricated	After 250 hour Aging at 500F
RT	1110 psi	—
400 F	1150 psi	—
450 F	990 psi	—
500 F	990 psi	480 psi

(b) The stress-rupture strength of Metlbond 316 has been determined as follows:

Test Temp.	Stress-Rupture Strength in psi for 250 hrs.
200 F *	900
400 F	800
450 F	550
500 F	450 **

* After heat aging 250 hrs. at 450 F
** Obtained on material first submitted by Narmco Lab but not duplicated on production material

This work is being performed under U.S.A.F. sponsorship by the Los Angeles Division.

MA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: High Temperature Structural Adhesives for Metal Sandwich

3. OBJECTIVE:

To evaluate and develop high temperature structural adhesives for use in bonding metal-to-metal or sandwich composites for use at 600 to 600F.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

A high temperature adhesive is being developed in cooperation with Rubber and Asbestos Corporation. The adhesive is being compounded by R & A, and evaluated at NAA. The basic formulation will be similar to the epoxy-silicone-phenolic previously evaluated. The major differences will be in the carrier used, to permit a lighter weight film, and in the use of wetting agents to enhance adhesion to the steel. Various types of integral heated tools for bonding panels are being considered. The tools will simulate production methods used for bonding.

This limited-magnitude program is Company-sponsored, and is approximately 35% complete. Estimated completion date is 1 October 1962, by the Columbus Division.

MATERIALS RESEARCH PROJECT SUMMARY

Period:

Material Classification: Adhesives

Materials: Metlbond 406, Pro Seal 777-1, APCO 1219, Narmco 3135, Resiweld No. 4, EC-1956, ~~EC-1466~~, AF-32, AF-40, AF-41, FM-1000, Metlbond 4041, A-4

Title: An Evaluation of the Mechanical Properties of Adhesives at Cryogenic Temperatures and their Correlation With Molecular Structure.

Project No. RFA 111-9206

Objective:

1. To determine the mechanical properties of various adhesives used on several adherends when tested at cryogenic temperatures. The tests to be used are lap-shear, butt-tensile, impact, and T-peel tests on metal-to-metal bonds.

2. To correlate the chemical compositions and molecular structures of adhesives with properties of their metal-to-metal bonds at cryogenic temperatures.

Results and Conclusions: Five classes of adhesives were selected for evaluation at cryogenic temperatures on the basis of promising high lap-shear strengths at -65°F and 75°F. Lap-shear specimens were tested at -423°F, -320°F, -100°F, and 75° utilizing epoxy-nylon adhesives (Metlbond 406, AF-40 and FM-1000), nitrile-phenolic adhesives (Metlbond 4041 and AF-32), epoxy-polyamide adhesives (Resiweld No. 4 and Narmco 3135), an epoxy-phenolic adhesive, (Metlbond 302-A), and a polyurethane adhesive (APCO 1219). Selection of adherends for testing was based on the anticipated use of these materials in future missiles and spacecraft, the prevalent use of some of these materials in the Atlas and Centaur, and the promising cryogenic properties of the base materials. The adherends utilized were: 0.020" EFH 301 CRES, 0.064" 2024-T3 bare aluminum, 0.020" A-110-AT titanium, 0.125" Conolon 506 (phenolic-fiberglass laminate) and 0.125" Conolon 527 (polyester-fiberglass laminate). Butt-tensile tests were conducted with 3/4" round stock 321 stainless steel and AF-40 epoxy-nylon adhesive.

Results and Conclusions: (continued)

The epoxy-nylon adhesives resulted in the highest lap-shear strengths with all adherends over the entire temperature range of -423°F to 78°F. Values obtained at -423°F are more than 100% higher than any previous reported values for similar tests. The nitrile-phenolic adhesives gave excellent results over the temperature range of -320°F to 78°F but dropped off sharply at -423°F. The epoxy-phenolic adhesives gave uniform results over the complete temperature range. These results were significantly lower than the epoxy-nylon and nitrile-phenolic adhesives at -320°F, -100°F and 78°F. At -423°F the epoxy-phenolic is superior to the nitrile-phenolics. Room temperature cured adhesives are generally inferior to those that are heat cured. Of the three room temperature curing adhesives tested, the polyurethane gave higher lap-shear strengths than the epoxy-polyamides with aluminum adherends and approximately the same strengths with stainless steel adherends. All the adhesives tested had their highest lap-shear strengths at -100°F.

MATERIALS RESEARCH PROJECT SUMMARY

Period: 1 September 1961 to 1 March 1962

Material Classification: Plastics and Adhesives

Materials: Metlbond 406, FM-1000, AF-41, Metlbond 409, Narmco 3170-7131, HT-424, Epon 828/Versamid 125

Title: An Evaluation of the Mechanical Properties of Adhesives at Cryogenic Temperatures and their Correlation with Molecular Structure

Project No. REA 111-9206

Objective:

1. To determine the mechanical properties of various adhesives used on several adherends when tested at cryogenic temperatures. Testing will include lap-shear, butt-tensile, impact, and T-peel tests on metal-to-metal bonds.

2. To correlate the chemical compositions and molecular structures of adhesives with properties of their metal-to-metal bonds at cryogenic temperatures.

Results and Conclusions: Lap-shear tests were run on joints containing 0.020" EFH 301 CRES adherends with both Metlbond 406 and FM-1000 adhesives. In both cases FM-1009-8 tack primer was utilized; results at -423°F were approximately 35% lower than those obtained without primer. Pre-Bond 700 (alkaline cleaner) etching prior to bonding was also evaluated and resulted in higher strengths than all other surface preparation methods. Lap-shear strengths of two new epoxy-nylon systems, tacky AF-41 and Metlbond 409, were also obtained at cryogenic temperatures. A new room temperature curing epoxy-polyamide system filled with finely ground nylon (Narmco 3170-7131) was evaluated with lap-shear specimens utilizing both 0.020" EFH 301 CRES and 0.020" 5Al-2.5Sn titanium alloy adherends. Lap-shear strengths at cryogenic temperatures were poorer than those obtained previously with unfilled epoxy-polyamide systems.

Impact specimens were prepared using Metlbond 406, HT-424, FM-1000, and 50:50 Epon 828/Versamid 125. The specimens were tested at 78° and -320°F, and the highest strengths were obtained with the Metlbond 406.

Results and Conclusions: (Continued)

Honeycomb specimens were evaluated in edgewise compression and in pi-tension. The face materials were 0.032" EPH 301 CRES and the core was Hexcel HRP 3/16 (5.5 lb/ft3). Specimens were bonded with FM-1000 and tacky AF-41, and they were tested at -320° and -423°F.

Ultrasonic equipment, initially designed by Dietz and co-workers at M.I.T. for the measurement of Young's Modulus of adhesives, has been modified and built. This equipment consists of a driving system to set up longitudinal ultrasonic vibrations in the specimens, a detecting system to indicate the amplitude of vibrations, and a frequency measuring system. This equipment has been checked out by determining the properties of 321 stainless steel and K-Monel.

VOUGHT AERONAUTICS

EVALUATION OF THE FEASIBILITY OF 15FA AND 15FE ZIRCONIA CEMENT FOR NOSE CAP APPLICATIONS

INTRODUCTION

The 15FA and 15FE zirconia cement formulations are promising materials for nose cap applications. Inconsistency in testing these formulations has been evident in the past. This evaluation is intended to correct the problems associated with those formulations by very close control on processing during this program.

Tests run during this evaluation were erosion, compression load, and thermal shock on small specimens. Percent shrink, and density were calculated and crystal structure was determined by X-ray diffraction analysis.

OBJECT

To ascertain whether the 15FA and 15FE zirconia cement formulations will be feasible for future use in nose cap applications.

DESCRIPTION OF TESTS

1. All the dry ingredients were mixed together and blended for one hour on a roll mill. The binder was added and hand worked to coat all grains.

2. After the cement was mixed to a workable consistency the cement was pressure rammed or a hand rammed in the proper molds and holders.

3. All specimens were cured at the same time using the same cure cycle. During various phases of the cure cycle temperatures were monitored with thermocouples imbedded in the zirconia cement, the furnace temperature and an optical pyrometer. The agreement between these readings was very good being within 20°F of one another.

Control specimens for each cement formulation were removed from the furnace after each step of the cure cycle in order to check weight loss.

4. X-ray diffraction analysis of the zirconia materials (as received, the 15FA and the 15FE composition unfired and fired) were run for the percent cubic and monoclinic phases.

CONCLUSIONS

The 15FA zirconia cement formulation exhibited the most desirable properties of the two formulations evaluated.

The 15FE zirconia cement formulation was undesirable due to fluxing and lowering of the melting point caused by excess binder.

It is necessary to modify the formulation and/or processing of the low modulus cement (basic 15FA type) so as to restrict crack propagation without adversely affecting the low modulus, thermal shock behavior, refractoriness, or erosion resistance demonstrated by the 15FA type cured at 2500°F.

It is desirable to shorten the curing cycles if possible to minimise degradation of the siliconized graphite holder.

REFERENCE

Chance Vought SLTR 61-53430-136 dated 8 July 1961

OPTIMIZING CVC CEMENT FORMULATION 15FA BY COMPONENT MODIFICATION

INTRODUCTION

Earlier test work indicated that further studies should be made in answering questions of how to lower the modulus while retaining other desirable properties. Present data indicates a 15FA mixture using Y710 as a binder is feasible making elimination of the 2500°F cure cycle possible. Additional variables in question are how the following affect modulus: (a) smaller zirconia bubbles, (b) increased amount of zirconia bubbles at the expense of ZrO_2 powder, (c) increase in porosity using microballoons, (d) use of fibers in conjunction with balloons as void formers or crack stoppers, and (e) removal of coarse particles from the ZrO_2 powder.

OBJECT

1. To obtain a high temperature low modulus cement which resists erosion and will withstand thermal shock with a minimum amount of shrinkage.

2. To further determine the mechanics and limits in formulating a high temperature low modulus cement.

DESCRIPTION OF TESTS

All formulations were dry mixed on a roll mill for a period of thirty minutes. The binder was added and hand mixed. The mix was immediately hand tamped and hand rammed into molds 1.0 inch long by 1.25 inch diameter.

All specimens were held at room temperatures overnight. All batches but one were then given various elevated temperature cure cycles.

Weights were taken after curing and measurements were made on 3 specimens of each batch before and after the cure cycle to determine shrink and density values.

Three specimens from each mix were tested in compression and two under thermal shock conditions. One specimen of each type was given a 4000°F shrink test, one was saved for a spare, and one kept for future reference.

Each of the specimens were weighed and measured before and after the 4000°F shrink test. These specimens were heated to 4000°F at 650°F/hour, held for one hour and furnace cooled.

CONCLUSIONS

The only formulation that passed all tests is the 15FA mixture with Y-710 binder cured at 1100°F.

The following deductions may be made from this test on high temperature low modulus cements:

a. Reducting Zr O_2 bubble size increases modulus.

b. Where bubbles are increased at the expense of Zr O_2 powder, modulus lowers but shrinkage increases.

c. Increase in microballoons lowers modulus.

d. Over 2% microballoons causes excess crumbling and increased shrinkage although modulus is lowered.

e. Elongated fibers assists in cracking, produces poor ramability and has a higher modulus than 15FA (silicate binders).

REFERENCE

Chance Vought SLTR 61-53430-144, 145, 146 dated 29 August 1961

COMPRESSION MODULUS AND THERMAL SHOCK TESTS OF VARIOUS CHANCE VOUGHT AND ZIRCOA CEMENT FORMULATIONS

INTRODUCTION

It is necessary to test several different formulas of Chance Vought Corporation and Zircoa cements to obtain one which contains all the desired properties such as low compression modulus and thermal shock resistance. The purpose of this investigation is to gain information leading toward improvement of 15FA or to find a more desirable cement.

OBJECT

To determine if Zircoa furnished cement formulations provide a better cement than 15FA.

To provide a more positive approach in formulating an improved 15FA cement by surveying various Chance Vought formulas in order to more completely understand the failing mechanism of high temperature low modulus cements.

DESCRIPTION OF TESTS

The Zircoa formulations were hand mixed, hand tamped, and hand rammed from molds to test specimen size (1.25 inch diameter x 1.0 inch length, and 2 inch by 2 inch by 4 inch slab).

The Chance Vought formulations were dry mixed for one hour in a roll mill and hand mixed after addition of liquids. The wet cement was then hand tamped into molds and hand rammed to form test specimens (same size as Zircoa).

The specimens were allowed to stand at room temperature for lengths of time ranging from two to eight days. This was followed by elevated temperature curing at temperatures up to 2500°F.

All specimens were examined, measured and weighed before and after the 2500 °F cycle. Shrink (or growth) and density values were calculated.

Three specimens for each type of cement were tested for compression modulus and for thermal shock resistance.

A specimen of each formulation was exposed to 4000°F for one hour and furnace cooled. They were measured, weighed and examined. Calculations of shrink or growth and density values were made.

CONCLUSIONS

All of the Zircoa formulations tested exceeded the desired 150,000 psi modulus value. The probable reason for this was the five grain zirconia powder and different binder.

Information obtained on the mechanics of high temperature low modulus cement indicates the following:

a. The cure cycle must begin within a minimum of two days after lay-up, preferably within eight to twenty hours.

b. The potassium silicate binder used is a better low modulus promoter than H_3PO_4 and Y-710 is better than Y-7111.

c. Voids are necessary, the more small voids the better.

d. Grain size or particle size effects the modulus.

REFERENCE

Chance Vought SLTR 61-53430-138 dated 4 August 1961

VOUGHT AERONAUTICS

Oct 61

RAMJET AND PROPANE TORCH TEST
OF ZIRCONIA CEMENTS

PURPOSE

The purpose of this test was to evaluate data collected from Zirconia specimens subjected to accoustical, pressure and temperature conditions. This test was conducted in four parts.

TEST SPECIMENS

The test specimen was a simulated leading edge with siliconized holder. A number of specimens were tested in this test procedure.

TEST PROCEDURES

PART: I Accoustical Damage Test

This test was conducted with the specimen mounted 18 inches from ramjet. The specimen was subjected to 157 db. overall sound level for 30 minutes.

PART: II Pressure Test

This phase was conducted in the ramjet facility with the specimen sting mounted. The controls were set for 12 lb/sec. air with a fuel-air ratio of .07. A maximum temperature of 400°F was recorded by the inner surface thermocouple.

PART: III Temperature Test

During this test the specimen was subjected to two different temperature-time profiles. The first had a maximum temperature of 2800°F and lasted about eight minutes. The second phase using different specimens had a peak temperature of 3000°F and lasted 40 minutes.

CONCLUSIONS

There was no apparent damage as a result of these four tests. Therefore, it may be concluded that these specimens withstood the test conditions as discussed. However, as outlined in Reference (2) a very similar test to this one was run in inverse order and considerable damage to the specimens was recorded.

REFERENCE

(1) CVA Test Request 61-59900-58 dated 16 March 1961.
(2) CVA Test Request 61-599900-70 7 April 1961.

MAXIMUM TEMPERATURE AND THERMAL SHOCK TEST OF THREE DIFFERENT ZIRCONIA CEMENT COMPOSITIONS

PURPOSE

The purpose of these tests was to obtain data to aid in selection of optimum zirconia cement composition and cure temperature. This was achieved by determining relative melting points and resistances to thermal shock.

TEST SPECIMENS

Three specimens of each of the three composition for each of the three curing temperatures were tested.

TEST PROCEDURE

The specimens were mounted in the propane torch facility and heated at 60°F/Sec. with torch in a fixed position until the temperature stabilized, then the torch was advanced at a rate to give 20°F/Sec. All surface effects and temperature at which effects occurred were recorded.

CONCLUSIONS

Cure Temp.	Type I	Type II	Type III
1000°F	3 crumbled in 2 min. at 4000°F.	No failures in 4 min. at 4500°F.	2 crumbled in 3 min. at 4250°F.
2000°F	3 crumbled in 3 min. at 4200°F.	No failures in 4 min. at 4200°F.	3 crumbled in 3.3 min. at 4200°F.
3250°F	No failures in 4 min. at 4200°F.	No failures in 4 min. at 4200°F.	No failures in 4 min. at 4200°F.

The above are average values for the specimens tested. This data indicates the compositions that failed and the ones that passed this thermal shock test. The torch was cut off after four minutes of testing.

REFERENCE

CVC Test Request 61-599900-64 dated 30 March 1961.

Oct 61

COMPRESSION MODULUS AND THERMAL SHOCK TESTS OF VARIOUS VOUGHT AND ZIRCOA CEMENT COMPOSITIONS

PURPOSE

The purpose of this test was the comparison of Vought and Zircoa Cements. The properties studied were compression load-deflection relationships and thermal shock characteristics.

TEST SPECIMEN

Seventy specimens were used in this test with 40 being of zircoa compositions and 30 of Voughts various compositions.

TEST PROCEDURE

Each specimen was tested in compression to failure by standard procedures at room temperature. Any specimens exhibiting the property of E less than 150,000 was then to be thermal shock tested from a nwe specimen of the same composition. The thermal shock test was a two level temperature vs time profile up to a maximum temperature of 4300°F and back to room temperature.

CONCLUSIONS

All Zircoa specimens had E values of 150,000 or more except one model. Five Vought specimens have E values of less than 150,000. These five were then tested by the thermal shock conditions outlined above, and all failed during the test program.

REFERENCE

CVC Test Request 61-59900-105 dated 12 June 1961.

COMPRESSION STRESS-STRAIN TESTS FOR ZIRCONIA CEMENT OPTIMIZATION

PURPOSE

The purpose of these tests was to provide data to aid in the selection of an optimum Zirconia cement composition and curing temperature.

SPECIMENS

Sixty-three compression specimens 1.25 inches in diameter by one inch in length were fabricated. Twenty-one specimens were subjected to a curing Temperature of 1000°F, twenty-one were cured at 2000°F, and the remaining twenty-one specimens were cured at 3250°F.

TEST PROCEDURE

All specimens were instrumented to record load vs. strain data. Tests were conducted between the loading heads of a hydraulic test machine. All specimens were tested to failure at room temperature.

CONCLUSIONS

Compression ultimate strengths and modulus values were obtained for all specimens and the type of failure was recorded. A surface yielding type failure was predominant in the test results (approximately two-thirds of the specimens failed in this manner) with brittle failure occurring in approximately twenty percent of the specimens. In all cases, regardless of the cement formulation, the highest strengths were exhibited by the specimens which had been cured out at 3250°F.

REFERENCE

Chance Vought Test Request 61-59900-46 dated 28 February 1961.

Oct 61

COMPRESSION LOAD-DEFLECTION TESTS
TO DETERMINE OPTIMUM ZIRCONIA CEMENT

PURPOSE

The purpose of these tests was to aid in selecting the optimum composition for a Zirconia cement by determining the load deflection characteristics of various compositions.

SPECIMENS

Twenty-seven specimens from nine different Zirconia cement compositions were fabricated. These specimens were 1.25 inches in diameter by 1.0 inches long.

TEST PROCEDURE

All test specimens were instrumented to furnish load vs. strain data to failure. Tests were conducted between the loading heads of a hydraulic testing machine. All tests were conducted at room temperature.

CONCLUSIONS

Ultimate compression strength and modulus values were recorded for all test specimens. Failing load values ranged from 15,000 pounds to 34,000 pounds with the average for all specimens being 23,850 pounds. Brittle failures predominated with about thirty percent of the specimens failing laterally due to Poissons Ratio effects.

REFERENCE

Chance Vought Test Request 61-59900-48 dated 3 March 1961.

COMPRESSION LOAD-DEFLECTION TEST FOR THREE DIFFERENT ZIRCONIA CEMENT COMPOSITIONS

PURPOSE

The purpose of these tests was to determine the compressive elastic properties of three types of Zirconia cements to assist in selection of a more realistic optimum cement composition for Zirconia structures.

TEST SPECIMENS

Cylindrical test specimens of the three types were formed. Three specimens of each composition of lack of the three cure temperature levels were tested. Cure temperature levels were 1000°F, 2000°F, and 3250°F. Specimens were about 1.0 in. long and 1.25 in. in diameter.

TEST PROCEDURE

Each specimen was loaded in compression until failure. The corresponding load-deflection curve was recorded.

CONCLUSIONS

	Type I (F_{CU})	Type II (F_{CU})	Type III (F_{CU})
Cure 1000°F	7,800	2,300	115
Cure 2000°F	1,800	2,560	2,500
Cure 3250°F	135	7,960	9,850

The above F_{CU} values are average values from the three specimens for each type and cure temperature. All cross sectional areas were about the same based on a 1.25 in. diameter so that the above data yields obvious conclusions concerning the desirability of composition.

REFERENCE

CVC Test Request 61-59900-63 dated 30 March 1961.

Oct 61

A COMPRESSION TEST OF TWO ZIRCONIA CEMENTS

PURPOSE

The object of these tests was to determine the compression strength, stress-strain characteristics, thermal shock resistances, and erosion resistances of two Zirconia cements which have been cured at a temperature of 2500°F.

TEST SPECIMENS

A number of specimens for each of the test phases mentioned were used in this series of tests.

TEST PROCEDURE

A compression-to-failure test and a thermal shock-erosion test were conducted. In this first phase, the specimens were compressed to failure; and in the second phase, a two level temperature-time profile was used with a maximum temperature of 4100°F.

CONCLUSIONS

The following average values were determined from the compression test.

Type I (Hand-Ram Mold)	F_{CU} = 1,070 E = 108,000	Type I (650 psi Mold)	F_{CU} = 370 E = 330,000
Type II (Hand-Ram Mold)	F_{CU} = 2,260 450,000	Type II (650 psi Mold)	F_{CU} = 930 E = 195,000

The results of the thermal shock-erosion test indicated two out of three failures for both types of cements used in this test. However, Type No. I showed good surface erosion resistance since all the failures in this group were side failures and all the difficulties encountered with Type No. II were face failures.

REFERENCE

CVC Test Request 61-59900-93 dated 19 May 1961.

Oct 61

PRELIMINARY EVALUATION OF MINNESOTA MINING AND MANUFACTURING AF-110 ADHESIVE USING VACUUM BONDING PRESSURE

INTRODUCTION

The bonding of metal to metal details using an adhesive system that can be bonded under vacuum pressure only is of special interest. Such a system eliminates the need for expensive equipment such as autoclaves, presses, and supporting equipment. AF-110 adhesive is reported to be a system which will bond under vacuum pressure only.

OBJECT

The object of these tests was to determine the lap shear bond strength of AF-110 adhesive bonded under vacuum pressure.

DESCRIPTION OF TESTS

A series of one-inch wide specimens having one inch overlap for bonding were fabricated from 0.064 7075-T6 aluminum alloy sheet as described below:

a. The aluminum plates were cleaned per standard procedures.

b. AF-110 Bonding tape was applied between the faying surfaces.

c. The test panels were bagged and a vacuum pressure of 27 inches mercury was applied and maintained throughout the cure cycle.

d. Bond line temperature was raised to 350°F for one hour.

e. Specimens were removed from the bonded panels. These specimens were one inch wide with a nominal one inch overlap.

CONCLUSIONS

The 0.063 clad 7075-T6 aluminum alloy lap shear bond strength of AF110 adhesive with a one inch overlap, bonded under vacuum pressure only, averaged 3220 psi (high 4000 - low 2100 psi). These facts indicate that this material and process merits further investigation.

REFERENCE

Chance Vought SLTR 61-53430-70 dated 17 April 1961

1. MATERIAL CLASSIFICATION: Transparent Materials

2. TITLE: Development of High Temperature Edge Attachments for Soda Lime Plate Glass for Use as Aircraft Windows

3. OBJECTIVE:

An extensive program to develop integrally bonded tensile edge attachments for high temperature windshields and windows is being conducted. The program includes evaluation of organic adhesives and ceramic cements for bonding metallic materials to glass.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The following data summarize achievements to date:

	Strength lb/in				
	-65F	RT	400F	500F	600F
Organic bonded edge attachments	1020	640	780		
Ceramic bonded edge attachments	625	450		400	

This work is being conducted by the Los Angeles Division under U.S.A.F. sponsorship.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION: Jan 61

ELASTOMER; RUBBER COMPOUND; BAC #5-0081
(ADIPRENE "C", POLYUREATHANE BASE)

DESCRIPTIVE TITLE:

Testing of Oxygen System "O" Ring Material

OBJECTIVE:

To determine the changes in physical properties of BAC compound #5-0081 after exposure to oxygen for 72 hours.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The physical properties of rubber compound BAC #5-0081, compounded for BMS 1-26, were determined before and after exposure for 72 hours at 160°F to oxygen at 2000 psi. Samples were exposed to the oxygen environment in both stressed (25% elongation) and unstressed conditions. The tests results indicated that the oxygen environment was not detrimental to the physical properties of BAC compound #5-0081.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

Jan 61

ELASTOMER; SILICONE; GASKET SEALS

DESCRIPTIVE TITLE:

Improvement of High Temperature Properties of Silicone Rubber Materials for Gasket Applications

OBJECTIVE:

The objective of this investigation was to improve the high temperature (400°F) compression set of Dow Corning LS-53, fuel resistant silicone.

ABSTRACT OF RESULTS AND CONCLUSIONS:

At 400°F the compression set of LS-53 is approximately 90-95%. This set is too high to effectively utilize this fuel resistant silicone as a flat gasket type seal in such applications at fuel tank access doors. By blending 30 parts of Dow Corning S-2096U low compression set silicone with 70 parts of LS-53, it was possible to lower the compression set to 22% at 400°F. The volume swell of LS-53 in type III fuel after 70 hours at 70 ± 5°F is 28%, and the swell of the blend is 66% which can be tolerated in many gasket applications.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

Jan 61

MATERIAL CLASSIFICATION:

ELASTOMER; SILICONE; TEMPERATURE CAPABILITIES

DESCRIPTIVE TITLE:

Feasibility of Modifying Silicone Rubber for Increased Temperature Capabilities

OBJECTIVE:

The objective of this work was to evaluate the possibility of improving the high temperature capabilities of silicone rubber by mechanical-chemical modifications.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A survey of the literature on reactions caused by mechanical forces on rubber was completed. Some information on graft co-polymerization and adduct rubbers was also obtained. From this information it was evident that reaction sites are formed in a polymer by intense mechanical forces. These forces generally form reaction sites by a scission mechanism in the polymer chain. Block polymers have been formed by mastication together of two polymers or a polymer and monomer. Degradation of polymer chains also occurs particularly if oxygen or reactive solvents are present.

An attempt was made to improve the high temperature capabilities of a silicone elastomer. SE 33 silicone gum stock was hot milled on a micro rubber mill with titanium dioxide in a nitrogen atmosphere. The resulting rubber was compared with a control by determining the stress relaxation as the temperature was raised from 80°F to 650°F over a period of 140 minutes. Both the initial stress (at 20% elongation) and the drop in stress were practically the same for both samples.

Mechanical forces can be used to obtain a wide range of graft co-polymers. No specific information was found on the incorporation of metallic components in a polymer. The limited experimental work conducted indicated that more intense mechanical conditioning or higher temperatures must be used to alter the characteristics of the silicone rubber.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

Jan 61

MATERIAL CLASSIFICATION:

ELASTOMER; SOLID AND FOAM; MOBILE MISSILE HARNESS

DESCRIPTIVE TITLE:

Mobile Missile Harness - Minuteman

OBJECTIVE:

To locate or develop materials which meet specific load-deflection requirements for the continuous support harness for the mobile concept of the Minuteman Missile.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Several types of rubber and flexible plastic material configurations were tested, to determine their load-deflection characteristics, this included the following: Neoprene rubber, BMS 1-11 grades 40 and 60 (molded in various configurations such as waffle and ripple shapes), sponge and foam rubber, and polyvinylchloride honeycomb.

All of these materials varied a great deal in load-deflection characteristics. The materials such as foam and sponge were quite stable and exhibited a very steady rise in the psi required to obtain specific deflections. The hardness or density of the material was the determining factor in the slope of the load versus deflection curve. The polyvinyl chloride honeycomb and the waffle configurations of the BMS 1-11C Neoprene rubber had quite different characteristics than those of sponge and foam or solid slab rubber. The initial load versus deflection curve was comparable to those of the sponge and foams only up to the point where the column strength of the vertical webs gave way to buckling. At this point the force required to deflect the specimen remained almost constant until the material in its crushed state again began to compress and the load required to deflect the material increased rapidly. The thickness of the web or column and the hardness of the material was the determining factor in this case. BMS 1-11, grade 40 molded in a waffle shape 1/2" thick met the desired load deflection requirements.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

Aug 61

MATERIAL CLASSIFICATION:

ELASTOMER, HOSE MATERIAL, HYDRAULIC; COMPARATIVE SERVICE STUDY

DESCRIPTIVE TITLE:

Hydraulic Hose Service Study

OBJECTIVE: The object of this program (flight test) was to determine the comparative service life of Teflon hose to that of rubber hose installed in the spoiler system of the B-52 airplane.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The hose record revealed that the rubber hose assemblies suffered 58 failures during 203.5 hours of flight time as compared to 24 failures experienced by the Teflon hose assemblies during 199.5 hours of flight time. Corrective action for the 58 rubber hose failures resulted in 37 hoses being replaced, 12 being corrected by retorquing the hose end fittings, and nine being wiped clean of hydraulic oil with no further action. In contrast to the rubber hose, the 24 failures experienced by the Teflon hose resulted in two hoses being replaced, 21 being corrected by retorquing the hose end fittings, and one being wiped clean of hydraulic oil with no further action.

Teflon hose assemblies are more resistant to flexure failure and end fitting seepage. Teflon hose assemblies, when properly installed, more than justify the cost differential over rubber hose assemblies because of their longer service life, as well as longer shelf life. These features combine to improve airplane reliability and curtail maintenance time.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

Aug 61

MATERIAL CLASSIFICATION:

ELASTOMER; NEOPRENE, NITRILE, BUTYL; SOLVENT SWELLING

DESCRIPTIVE TITLE:

Surface Effects of Fluids on Elastomers Under Stress

OBJECTIVE:

To determine the cause of failure of stressed elastomeric parts in contact with solvents, and to attempt to devise protective techniques to prevent such failures.

ABSTRACT OF RESULTS AND CONCLUSIONS:

In the present study, the rupture of rubber in tension in various liquids was observed with respect to degree of elongation, time, size of specimen, time of relaxation, and various proposed protective pretreatments. Swelling rates and equilibria, desolvation rates, tensile and tear strength, and ultimate elongation were measured.

Swelling weakens rubber to a major and predictable degree, depending upon the rubber and fluid used.

The time to failure was variable within a set of specimens treated identically. This was interpreted as due to the importance in initiating failure of randomly distributed flaws at varying positions within the rubber.

A number of chemical surface treatments were studied. None of these showed significant protection of the parts.

The results of this work are reported in the Boeing Document D2-10241 "Surface Effects of Fluids on Elastomers Under Stress".

1. MATERIAL CLASSIFICATION: Seals & Sealants
2. TITLE: High Temperature Integral Fuel Tank Injection Sealant
3. OBJECTIVE:

Evaluate injection sealants to determine resistance to 350°F in conjunction with aircraft fluids and environmental conditions.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The Dow Corning Corp. reformulated the initial groove sealant (Q9-0008) four times, which resulted in attaining desirable properties and subsequent production utilization of the last formulation, designated Q9-0048. No other sealant manufacturers submitted samples for evaluation.

Q9-0048 has excellent temperature resistance to 400°F for 30 days, and to JP-5 fuel at 140°F for 30 days. Its viscosity is low, resulting in faying surface extrusion in areas where gaps exceed 0.004 inch. The manufacturer is currently evaluating procedures to increase the viscosity without greatly altering the other properties.

This work, sponsored by the Bureau of Naval Weapons, is of extensive magnitude, and is approximately 50% complete. The program is being conducted by the Columbus Division.

1. MATERIAL CLASSIFICATION: Seals and Sealants

2. TITLE: Testing RTV-60 and CA9R for Sealing Electrical Terminations for Use at 550° F and 650° F, Respectively

3. OBJECTIVE:

Preliminary laboratory investigations had shown that RTV-60 and CA9R might be used at 550° F and 650° F for potting and/or encapsulating electrical switches and connectors. Four high temperature Bendix BT connectors were potted - two with RTV-60 and two with CA9R according to established procedures. These were then subjected to extensive environmental testing to determine their elevated temperature performance.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

No failure occurred after potting; the connectors satisfactorily passed room temperature, high potential, insulation checks for leakage. Exposure to test temperatures for 200 hours, and thermal shock cycling also produced no leakage failures. After humidity exposure per MIL-C-5015D both connectors subjected to 650F and one exposed to 550F failed the leakage tests. This U.S.A.F. sponsored effort was conducted by the Los Angeles Division.

NA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: **Seals and Sealants**

2. TITLE: **Preliminary Evaluation of Material for Engine Air Guide Seal**

3. OBJECTIVE: Tensile properties of Teflon (TFE) impregnated asbestos sheet (.042 inches thick) will be measured at room temperature before and after aging 25, 50, and 150 hours at 630 F. Tensile properties will also be measured at 630 F before and after aging 25, 50, and 150 hours at 630 F.

4. ABSTRACT OF RESULTS OR CONCLUSIONS: Typical data derived from this limited program are presented as follows:

Weave	Test Temp.	Tensile Strength (psi) After Aging at 630 F		
		0 hrs	50 hrs	150 hrs
Warp	RT	2660	2250	1170
Warp	630 F	1515	1330	805
Fill	RT	1545	1280	570
Fill	630 F	980	700	450

The program was conducted by the Los Angeles Division under U.S.A.F. sponsorship.

NA-61-1049-2
4-15-62

1. MATERIAL CLASSIFICATION: Seals and Sealants.

2. TITLE: Bulkhead Sealing of Wire Bundles

3. OBJECTIVE: This limited program is being conducted to select a sealing compound from several candidate materials for the purpose of sealing wire bundles which pass through aircraft bulkheads. The sealing compound must be effective in minimizing air leakage and must operate during and after exposure to 650 F for 200 hours. Candidate materials to be investigated include:

   1. CA9R - Englehard Industries, Inc.
   2. Sauereisen 31 - Sauereisen Co.
   3. R-7521 - Dow Corning Co.

4. ABSTRACT OF RESULTS AND CONCLUSIONS: No data have been generated to date. This program is being conducted by the Los Angeles Division under U.S.A.F. sponsorship.

GENERAL MATERIALS INFORMATION - PHASE II
MATERIALS WORK IN PROGRESS

TITLE: High Temperature Elastomeric Sealants

OBJECTIVE: To obtain mechanical property data on elastomeric sealants for use at high temperature.

MATERIALS: Pro-Seal 700 and 714, Coast Pro-Seal & Mfg. Co. (83527)
EC 1689 & EC 1691, Minn. Mining & Mfg. Co. (04633)
PRC 1910, Products Research Co. (99891)
Chem Seal 3802, Chem Seal Corporation of America
RTV-90, General Electric Co., (01139)
20078, 30121, 20046, and 20103, Dow Corning Corp. (71985)

PROGRAM PLAN: To evaluate all sealants with regard to flow temperature, fuel resistance (JP-5), MIL-L-7808 oil resistance, adhesion to metallic and non-metallic surfaces, and density.

RESULTS: Flow and lap shear test results for single specimens are noted below, after room temperature cure of 24 and 92 hours respectively.

Note: There is no relationship between the arrangement of compounds in the Material listing and the tabular results.

Flow 24 hour Cure	Lap Shear Strength, 92 hour Cure					
	As Cured	MIL-L-7808 Immersion		Dry Heat Exposure		
		24 hours RT	2 hours 300 F	2 hours 400 F	2 hours 500 F	50 hours 400 F
inch	psi	% Chg	% Chg	% Chg	% Chg	% Chg
no sag	378	-34.6	none	+15.3	-47.0	-23.5
.1	540	nil	-35.1	-29.6	-80.3	-50.9
.1	555	-20.7	-48.6	-37.8	-83.2	-40.5
.1	384	-25.6	-33.5	-42.4	-89.5	-42.7
.2	217	-14.7	-11.3	-54.3	-82.9	-10.7
no sag	16	-50.0	+193	+450	+318	+368
1.7	not tested, sag was excessive					
2.2	not tested, sag was excessive					

DATA SOURCE: Northrop Corp., Norair Division (76823) Index No. 334

GENERAL MATERIALS INFORMATION - PHASE II
MATERIALS WORK IN PROGRESS

TITLE: Development of Low Density Elastomeric Sealants

OBJECTIVE: To develop low density weather sealants conforming to the performance requirements of Specification MIL-S-8802.

MATERIALS: Elastomeric sealants, primarily of polysulfide base compounds with low density fillers and additives.

PROGRAM PLAN: Currently supplied sealants exhibit a nominal specific gravity of 1.4. This program is to stimulate manufacturers of compounds to develop lower density sealants, aiming at a specific gravity of 1.0 or lower.

RESULTS: Four manufacturers of sealing compounds have submitted a total of seven new compounds to be tested. These are based on polysulfide and silicone rubber gums. The polysulfide compounds all showed excessive ackiness after full cure, so that stacked peel specimens were difficult to separate. Heavy applications of talc were necessary to overcome the tackiness. The silicone rubber compounds do not exhibit this cured tackiness. New test specimens will be required in order to determine the properties of these compounds.

The compounders have indicated that different fillers must be investigated in order to achieve low density and maintain the mechanical properties desired, with no adverse surface tackiness. It would be impractical to require frequent applications of talc in service to reduce the tackiness. Development of compatible surface coatings might allow the use of tacky surface compounds, if the compounds were otherwise satisfactory.

ESTIMATED COMPLETION DATE: 15 June 1962.

DATA SOURCE: Northrop Corp., Norair Div (76823)

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

Jan 61

MATERIAL CLASSIFICATION:

CHEMICAL; SEALANTS; GENERAL; TEMPERATURE RESISTANCE

DESCRIPTIVE TITLE:

Investigation of High Temperature Sealants

OBJECTIVE:

To investigate and evaluate new materials and methods for sealing aircraft structures which are exposed to high temperatures resulting from increased aircraft speeds.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A. New Material Evaluations:

Two fuel resistant sealants are presently being investigated: a one part silicone (Dow Corning Q-3-0046), and a Minnesota Mining Polymer EC-1946 (formerly "Polymer B"). EC-1946 depolymerized after fuel and salt water exposures of 7 days at 180°F and 250°F. The one-part silicone has poor water resistance and exhibits low cohesive strength (4 lbs/in.) after fuel immersion; however, it is believed to be the best filleting sealant tested thus far for sealing fuel tanks exposed to temperatures above 300°F.

B. Polymer Preparation:

Two general types of compounds have been investigated for use as elastomers of superior temperature resistance, and a number of syntheses have been performed:

The first group investigated has been the polyesters of the three phthallic acids with the dihydroxy benzenes and phloroglucinol.

The second study has been an attempt to incorporate an aromatic oxide group into a chain with carbonyl esters, aromatic ether and polyaromatic linkages. All three types have been prepared in preliminary syntheses, but evaluations and improvement of methods are incomplete.

Type of Program: Engineering Evaluation

Material Classification: Sealants

Descriptive Title: Integral Fuel Tank Sealants

Objective: This study was initiated to evaluate sealants for integral fuel tanks for operating temperatures ranging from -67° to 400°F.

Abstract of Results and Conclusions: A screening test of several basic sealants such as silicones, vitons, and polysulfides was conducted to determine the suitability of various sealants for application to integral fuel tanks operating at temperatures ranging from -67° to 400°F. Results of the screening program showed that Products Research Corporation's sealant PR1730 (a Viton A base compound) was the only sealant capable of satisfying the temperature requirements. Additional evaluation of PR1730 sealant was conducted in accordance with Specification MIL-S-8802B with modifications as suggested by AIA Specification ARTC-13. Results of these tests showed that PR1730 sealant with PR1734 primer was unsatisfactory for integral fuel tanks in view of the poor adhesion characteristics and mode of failure during peel tests. For the above sealant system, peel load required to initiate an adhesive failure was 10 to 20 pounds per inch. However, the peel load required to propagate the failure was 3 to 5 pounds per inch.

Additional tests were conducted employing a two-part primer system, PR1732 and PR1733. The mode of failure was similar to the previous systems tested but the initial adhesive failure load was 30 to 45 pounds per inch. Load required to propagate the failure was the same as in previous tests. Additional investigations are being conducted to improve the adhesion characteristics of this sealant system.

TR 50-1970 (Corporate Funded)

TITLE Sealants - Composite Metal-Fiber O-Rings and Flexible Metal Seal - For High Temperature Use

OBJECTIVE To develop a fuel sealing system for future aircraft designed for high speed flight including space and re-entry operations in the temperature range of -100°F to 1200°F.

DISCUSSION The purpose of this program is to investigate the sealing properties of composite metal-fiber O-rings and flexible metal seals. Testing will first be performed at room temperature with air pressure. If a satisfactory seal is obtained under those conditions, testing will be performed with air pressure at -100°F and 1200°F. If that testing proves successful, testing will be performed with pressurized fuel and then at the high and low temperatures

RESULTS The work performed has been to make a preliminary evaluation of a composite metal-fiber O-ring supplied through a request to ASD by the Armour Research Foundation of Chicago, Illinois. The O-ring was placed between two machined steel plates in a hydraulic press with a 40,000 pound load and with 20 psi internal pressure used to check for leakage. During that test, only one very small leak occurred.

A new composite metal O-ring has been requested from Armour Research for continuation of the testing It will have a stainless steel skeleton and will be fabricated by extruding the composite material through a die into a rod-like shape. This will then be formed into a circle with the ends joined by welding. The new O-ring is to be available in November 1962.

ESTIMATED COMPLETION DATE December 1962

TR 50-2344 (Funded Under the B-58 Contract)

TITLE: Material - Integral Fuel Tank Sealant - Swell Type - Development and Screening of

OBJECTIVE: To modify the composition of Products Research PR-9422 B 1/2 sealant so that after curing, it will swell when exposed to fuel.

DISCUSSION: The purpose of this test program is to investigate filler materials that can be added to PR-9422 B 1/2 sealant while in the uncured state to provide swelling of the cured sealant (15% to 25%) when exposed to fuel. A sealant with this expansion property is desired for use in sealing the structural voids of B-58 integral fuel tanks. In this application the present PR-9422 B 1/2, which does not swell when immersed in JP-4 fuel, has not provided adequate void sealing under all conditions. It is believed that if the sealant would swell 15-25% when contacted by fuel the voids would be completely sealed at all times.

RESULTS: The following elastomeric additives have been combined with PR-9422 B 1/2 sealant in an attempt to obtain swelling characteristics in the sealant: Midwest GF-30-M, U.S. Rubber #9316, B. F. Goodrich Resin #2007, B. F. Goodrich Liquid Buna-N 1300X2, Dow Corning DC 6508 and RTV5302-5303, and 3M Co EC-2288. Ten combinations using these materials have been prepared and are immersed in JP-4 in preparation for measurement of the samples

ESTIMATED COMPLETION DATE: December 1962

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

Aug 61

MATERIAL CLASSIFICATION:

ELASTOMER, SILICONE, DOW CORNING Q-3-0121; APPLICATIONS EVALUATION

DESCRIPTIVE TITLE:

One Part Room Temperature Vulcanizing (RTV) Silicone Rubber

OBJECTIVE:

To evaluate Dow-Corning Q-3-0121 Silicone as a weather and pressure sealant.

ABSTRACT OF RESULTS AND CONCLUSIONS:

It was found that Dow Corning Q-3-0121 silicone would adhere to some metals (stainless steel, bare aluminum, anodize, iridite, alclad) without a primer but that the adhesion bond failed after 2 weeks in warm water. Q-3-0121 was compatible with most silicone primers and other silicone elastomers but was corrosive to cadmium and copper because of its high acetic acid content.

It is concluded that Q-3-0121 is acceptable as a non-structural adhesive where the corrosiveness can be tolerated. It is not acceptable as a sealant because of its corrosiveness.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

Aug 61

MATERIAL CLASSIFICATION:

ELASTOMER, FLUOROSILICONE Q-2-0046; SEALANT, HIGH TEMPERATURE, EVALUATION

DESCRIPTIVE TITLE:

Q-2-0046 Fluorosilicone Sealant

OBJECTIVE: To evaluate Q-2-0046 Florosilicone as a high temperature fuel tank sealant.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The subject sealant was considered unsatisfactory for high temperature (250°F) fuel tank sealing, mainly because of poor adhesion after salt water immersion and low cohesive strength after fuel exposure.

Index No. 341
2-5546-0-9

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

Aug 61

MATERIAL CLASSIFICATION:

ELASTOMER; CRYOGENIC SEALS

DESCRIPTIVE TITLE:

Investigation of Elastomeric Materials as Seals for Service at Cryogenic Temperatures

OBJECTIVE:

To select elastomeric materials, indicating liquid oxygen compatibility, and to determine their most appropriate configuration and application techniques for use as seals for cryogenic systems.

ABSTRACT OF RESULTS AND CONCLUSIONS:

A survey of the literature on impact sensitivity of elastomeric materials indicated fluorinated elastomers provided the most resistance to detonation when impacted in liquid oxygen. As a result of this survey, Viton materials in the form of AN 6227-19 size O-rings were selected for testing purposes. The O-rings were compressed 40 to 90% of their original thickness between flat plates, immersed in liquid nitrogen and pressure tested to 1000 psig with helium gas. Results indicated that compression of 70 to 90% was required to produce a minimum leak (10^{-4} cc per hour) seal at 1000 psig while slightly less compression is required at lower pressures. Life at liquid nitrogen temperature was not determined but seals kept at this temperature 3 and 4 days showed no failure when dissassembled. Heavy plates are required to minimize warpage due to the resistance of the seals to high levels of compression.

Several vendors seals were also tested. The best results were obtained with spring loaded teflon-type seals.

Type of Program: Engineering Evaluation Oct 61

Material Classification: Seals, Fluids, and Sealants

Descriptive Title: High Temperature Hydraulic Evaluation Program

Objective: To evaluate dynamic and static seals, fluids, and components in an environment ranging from -65°F to +600°F at 3000 psi. (Contract AF33(616)-6066).

Abstract of Results and Conclusions: 0-rings molded from Viton and Fluorel (both fluorinated hydrocarbons) and Rulon (reinforced Teflon) were selected as the most suitable elastomers for evaluation. Back-up rings were fabricated from Duroid D5613, Rulon, and several other types of reinforced Teflon material. Standard glands and back-up rings were modified to extend service life of the seals. Metallic seals for dynamic and static applications were also evaluated. Mineral oils, both undewaxed and deep dewaxed types, were selected as test fluids. The latter was used during low temperature testing and component testings. Rod seals ranging in size from 1/2 to 2 inch rod diameter were generally subjected to short-stroke (1/4" stroke, 250 cpm) mechanical cycling at constant pressure (3000 psi), and long-stroke (2" stroke, 40 cpm) mechanical cycling with impulsing pressure (50 - 3000 psi). Thermal cycling (+ 70°F to 600°F and back to +70°F) was performed concurrent with mechanical actuation. Static seals were tested with continuous pressure impulsing (50 - 3000 psi, 40 impulses per min.) while undergoing thermal cycling.

Results have shown that -

(1) Service of elastomeric seals under these conditions depends primarily on the resistance of the material to loss of desirable mechanical properties.

(2) Viton 0-rings, compound nos. XWAV-5 and 1700-90, show the most promise in dynamic and static applications.

(3) Back-up rings of Duroid 5613 material were consistently reliable in dynamic sealing applications.

(4) Life of metallic seals in dynamic applications are limited due to their high shape rigidity resulting in the inability of the seal to conform to surface irregularities

(5) The deep dewaxed mineral oil is a promising fluid for 600°F operation.

The program has been completed, and a final report forwarded to WADD on March 31, 1961. Release of this report will be initiated by WADD under TR60-896.

1.0 Index Code . . . . (Plstc-6S)(II-j, k)

2.0 Title - T.R. No. 32A-013.01, Evaluation of Sealants to Eliminate Moisture in F-4H Bonded Honeycomb Sandwich Panels.

3.0 Objective - F-4H aircraft subassemblies aileron flap, stabilator, and outer wing panels containing honeycomb structures accumulate water in the honeycomb. The presence of water in these honeycomb structures was determined by X-Ray. The objectives of this test program are the following:

a. To evaluate the use of epoxy-polyamide or other sealants for sealing the glue lines by vacuum impregnation techniques on F-4H honeycomb assemblies.

b. To determine if the presence of water in the honeycomb structures is caused by condensation of water vapor due to cycling from low temperature and pressure at high altitudes and/or returning to humid sea level atmosphere.

The scope of this investigation includes the following:

a. Determination of pressure drop curves (pressure versus time) for all honeycomb assemblies both before and after sealing with epoxy-polyamide compounds.

b. After pressure drop tests are completed, conduct water immersion tests on all honeycomb assemblies.

c. Upon completion of the water immersion tests, subject each honeycomb assembly to the following temperature-vacuum-humidity cyclic test:

1. Weigh the honeycomb assembly.

2. Cool the honeycomb assembly to 20 $\pm$ 5°F.

3. Expose the honeycomb assembly to a vacuum of 25 inches of mercury.

4. Raise temperature of honeycomb assembly to room temperature.

5. Inject 80 to 90% relative humidity air into test chamber containing the honeycomb assembly.

6. Repeat steps 2 through 4 above for a total of 150 cycles.

7. Reweigh the honeycomb assembly and determine the amount of water accumulated during the 150 cycles.

4.0 Status and Results - The test work has been completed and the final report is being written. Test results indicate that approximately 8 grams of water have accumulated inside the honeycomb assembly after 150 temperature-vacuum-humidity cycles.

TITLE: Ablative Materials

SPONSOR: Bell Aerosystems Company

CONTRACT: Internal R&D

DURATION: One year

LEVEL OF EFFORT: Three man/years

PROGRAM: The program on ablative is on applied R&D program concerned with the development of all types thermally protective materials. The project is divided into three phases:

1. analytical studies
2. development of ablative formulations and materials
3. experimental laboratory evaluation.

Phases two and three are currently in progress with the first summary progress report scheduled for December.

Type of Program: Applied Research and Development

Material Classification: Miscellaneous Special Purpose Materials

Descriptive Title: Ablation Model Testing

Objective: To evaluate the ablation characteristics of various materials under various thermal loadings.

Abstract of Results and Conclusions: Preliminary ablation testing has been performed on various materials and model configurations. Materials evaluated included graphite, copper-phenolic-asbestos composites, teflon, and various reinforced resins. The tests, simulating specific thermal flight profiles, were run in a megawatt arc jet. Enthalpy levels of 4340 to 8550 BTU/lb have been studied in the presence of nitrogen, flowing at 2000 standard cubic feet per hour. Model test temperatures have exceeded 3200°F. Duration of testing has varied from 30 seconds to 2 minutes.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; EPOXY RESIN; EPOXIDE NUMBER

DESCRIPTIVE TITLE:

Epoxy Resin Testing

OBJECTIVE:

To determine epoxide number.

ABSTRACT OF RESULTS AND CONCLUSIONS:

To replace the slow, erratic dioxane-HCl method as specified in D-18024, 3.115, a simpler, accurate and the more reproducible method was deviced, based on the method of A. J. Durbetakis, "Analytical Chemistry 28:2000(1956)". The test requires the titration of an epoxy with hydrobromic acid dissolved in acetic acid.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

Jan 61

MATERIAL CLASSIFICATION:

PLASTIC; EPOXY RESIN DER332; ANHYDRIDE CURING

DESCRIPTIVE TITLE:

Anhydride Curing of Epoxy Resins

OBJECTIVE:

To determine if it is advantageous to cure epoxy resins with anhydrides instead of using amine agents as is customary at the present time.

ABSTRACT OF RESULTS AND CONCLUSIONS:

1. Nine different anhydrides were tried as hardeners. All except one (methyl nadic anhydride) were solids at room temperature.

2. Raising the temperature of the epoxy resin, DER 332, Dow Chemical Company, to permit dissolving and mixing the anhydrides shortened the gel time to the point where insufficient time remained for laying up for laminating.

3. Using a gelling temperature of 130°-150°C and a post-cure of 2 hours at 200°C, hard castings with good compressive strength were obtained with all anhydrides except maleic, which required an extra hour of post cure.

4. Trimellitic anhydride cures developed the highest compressive strength. Using 80% of the amount calculated stoichiometrically (one hydroxyl equivalent for each epoxide equivalent), an average compressive strength of 33,150 psi was obtained.

5. With most of the anhydrides tested, only 40% to 80% of the calculated amount was required to effect cures that were apparently complete.

6. The results are reported in Job Report AP-1-23.

1.0 Index Code . . . . $(Fabr-5-Plstc-20T_{D}-Rub-6)(IV-a,e)$

2.0 Title - T.R. No. 32-971, Determination of the Corrosive Effects of Pressure Sensitive Tapes Used on Hot Air Ducts.

3.0 Objective - Insulating blankets on hot air ducts are being held in place on F4H aircraft with pressure sensitive tapes. It is necessary to investigate the possible corrosion effects of pressure sensitive tapes used on 19-9DL and 321 stainless steel hot air ducts. The scope of this test program includes the following:

a. Wrapping of pressure sensitive tapes Polyken 290, Polyken 292, Permacel 211, and Mystick 8000 around 19-9DL and 321 stainless steel blanks.

b. Subjecting pressure sensitive taped specimens to 24 cycles as follows:

1. Hold at 500°F for 1 hour.

2. Air cool to room temperature.

3. Subject to 20 hours 95% to 99% relative humidity at 90°F to 95°F.

c. Visual examinations of exposed specimens for evidence of corrosion.

d. Metallographic examinations of exposed specimens for evidence of corrosion.

4.0 Status and Results - Test specimens have been prepared and temperature-humidity exposure cycle testing has just begun.

1.0 Index Code . . . . (Alwt-6)(Plstc-23,5) (1V-a,b)

2.0 Title - T.R. No. 513-355, Process Development for Two Part Polyurethane Integral Fuel Tank Coating Material

3.0 Objective - Integral fuel tanks require a fuel resistant coating on the metal surfaces inside the tank to prevent corrosion. Buna N coating is currently being used by MAC in integral fuel tanks, this particular coating is susceptible to micro-organism growth which can result in severe corrosion. A two-part polyurethane material has been recently developed which resists the growth of micro-organisms. The objectives of this test program are to evaluate a two-part polyurethane coating system with respect to pot life, cure rate, corrosion resistance and production application. The scope of this evaluation encompasses the following test phases:

a. Phase I - Determination of the effect on pot life of maintaining catalyzed material at room temperature and at controlled reduced temperatures.

b. Phase II - Determination of the effect of relative humidity on cure rate within a temperature range which normally occurs in a production area.

c. Phase III - Comparison of the flexibility and salt water and fuel resistance properties of material applied at maximum pot life with freshly mixed and applied material.

d. Phase IV - Determination of the effect of nitrogen atmosphere on cure rates under optimum temperature and humidity conditions.

e. Phase V - Determination of the effect on pot life of catalyzed material applied at room temperature but continuously stored at -10°F and -20°F.

f. Phase VI - To determine if a two-part polyurethane system is applicable by simulating the production processes of mixing, storage, pumping, and fill and draining.

4.0 Status and Results - This test program will begin when polyurethane material is received.

1.0 Index Code . . . . (Ti-1,Fabr-5,Plstc-6,BA)(I-b,i)(V-g)(Vl-a)

2.0 Title - T.R. No. 52-051.05, Structural and Thermal Shock Evaluation - Prototype Ablation Shield Backup Structure.

3.0 Objective - A prototype backup structure for an ablation shield has been fabricated and includes a commercially pure titanium ring around the periphery and a fiberglass honeycomb-phenolic, fiberglass skin structure. The objectives of this test program are to determine the following:

a. Bending strength and shear strength of the ablation shield backup structure at room temperature, 500°F and 700°F.

b. Effect of thermal shock at 700°F.

The scope of this investigation includes the following:

a. Bend tests of fiberglass sandwich specimens at room temperature, 500°F and 700°F.

b. Determination of the minimum length of bending specimen that can be tested to produce skin buckling instead of core shearing.

c. Core shear strengths of fiberglass honeycomb specimens at room temperature, 500°F and 700°F.

d. Adhesive shear strength properties between titanium ring and fiberglass sandwich.

e. Determination of the effects of 700°F thermal shock tests on quarter section of ablation shield backup structure.

4.0 Status and Results - The test work has been completed and the final laboratory report is being written. A summary of test results obtained is presented below.

a. Results of Bend Testing Fiberglass Sandwich

Position of Skin Specimen to Load	Test Temperature °F	Ultimate Bending Stress on Skin (KSI)	Location of Failure
Convex skin down	Room Temperature	32.4	Tension failure in convex skin
Convex skin up	Room Temperature	36.0	Tension failure in concave skin
Convex skin up	500	27.2	Compression failure in convex skin
Convex skin up	700	14.3	Compression failure in convex skin

The minimum length bend specimen which produces failure in the skins was determined to be 21 inches at room temperature.

b. Fiberglass Honeycomb Core Shear Test Results

Test Temperature	Ultimate Core Shear Stress (Attained (PSI)	Type of Failure
Room Temperature	230	Core Shear
	222	Core Shear
	245	Core Shear
500	179	Adhesive Shear
	178	Adhesive Shear
	166	Core Crushing *
700	79	Adhesive Shear*
	85	Core Crushing *
	112	Adhesive Shear
	142	Adhesive Shear

* Testing was conducted without loading blocks under ram.

c. Adhesive Shear Strength Between Titanium Ring and Fiberglass Honeycomb

Curing Pressure (PSI)	Test Temperature ^{o}F	Ultimate Shear Strength (PSI)
50	Room Temperature	1113
50	500	631
13	Room Temperature	1404
13	500	643

d. During thermal shock test of quarter section of ablation shield back-up structure at 700^{o}F, the bond failed between the titanium ring and the fiberglass honeycomb skin.

1.0 Index Code . . . .(Ti-1, Fabr-5,Plstc-6,13A)(I-i)(V-g)

2.0 Title - T.R. No. 52-051.05.01, Structural and Thermal Shock Evaluation - Prototype Ablation Shield Back-Up Structure

3.0 Objective - An 88.6 inch diameter back-up structure for a prototype ablation shield was fabricated and tested per T.R. No. 52-051.05. During a 700°F thermal shock test of a quarter section of this shield, the bond between the titanium ring and the fiberglass honeycomb skin failed. In an attempt to improve the bond strength, the surface preparation of the titanium ring has been changed and two different curing pressures have been used to fabricate two new partial shields. The objectives of this test program are to determine the bondline shear strength of the ablation shield back-up structure at room temperature, 500°F and 700°F and also to determine the effect of thermal shock at 700°F on quarter section of this shield. The scope of this evaluation includes the following:

a. Determination of adhesive shear strength properties between titanium ring and fiberglass sandwich construction.

b. Determination of the effects of 700°F thermal shock tests on quarter section of ablation shield back-up structure.

4.0 Status and Results - The test work has been completed and the final laboratory report is being written. A summary of test results obtained is presented below.

a. Thermal shock test at 700°F produced no detrimental effect.

b. Adhesive Shear Test Results

Curing Pressure (PSI)	Test Temperature °F	Average Shear Strength (PSI) Δ
50	Room Temperature	1113
50	500	631
13	Room Temperature	1404
13	500	643

NOTE: Δ Limited testing indicated that these shear strength values were low. Another test program is being initiated to determine if the specimen configuration caused the low strength values.

1.0 Index Code . . . . (Ti-1, Fabr-5,Plstc-6,13A)(I-i)

2.0 Title - T.R. No. 52-051.05.02, Structural and Thermal Shock Evaluation - Prototype Ablation Shield Back-Up Structure

3.0 Objective - The purpose of this test program is to compare the core shear strength and adhesive shear strength of fiberglass sandwich material from the prototype ablation shield back-up structure to flat fiberglass sandwich at room temperature and 500°F. The scope of this evaluation includes the following:

a. Shear strength of B stage cured and precured adhesive shear specimens of bonded fiberglass laminates in thicknesses of 0.050 inch and 0.200 inch at room temperature and 500°F.

b. Shear strength of flat-B stage cured, flat-precured and curved (Prototype ablation shield) B stage cured core shear specimens at room temperature and 500°F.

4.0 Status and Results - The test work has been completed and the final laboratory report is being written. A tabulated summary of test results obtained is presented below.

a. Adhesive Shear Test Results

Number of Specimens	Type of Curing	Thickness of Bonded Fiberglass Laminate (Inch)	Test Temperature °F	Ave. Shear Strength (PSI)
5	B Stage	0.050	Room Temperature	1384
3		0.050	500	1056
5		0.200	Room Temperature	2670
4		0.200	500	1200
6	Precured	0.050	Room Temperature	1590
3		0.050	500	707
5		0.200	Room Temperature	2650
4		0.200	500	648

b. Core Shear Test Results

Number of Specimens	Type of Specimen and Type of Cure	Test Temperature °F	Average Shear Strength (PSI)
3 3	Flat - B Stage	Room Temperature 500	223 182
3 3	Flat - Precured	Room Temperature 500	260 200
5 4	Curved (Prototype Shield) B Stage	Room Temperature 500	265 205

1.0 Index Code . . . . (Plstc-6/23-RL/FIP/SC)(I-b)
(Alwt-3, FIP/SC)(I-b)
(Ti-1, FIP/SC)(I-b)

2.0 Title - T.R. No. 513-323, Investigation of Mechanical Properties of Foam-In-Place Sandwich at Elevated Temperature.

3.0 Objective - To obtain fundamental design data for use of foam-in-place sandwich in primary structures at elevated temperatures of from 300°F to 600°F. The scope of this investigation will include determination of the following:

a. Edge compressive strength at room temperature, 300°F and 400°F of 0.030" thick Epoxy (F-161-11-1P81 Pre-Preg) glass fabric skin plus urethane foam-in-place sandwich construction specimens.

b. Edge compressive strength at room temperature, 300°F and 400°F of 0.016" thick 2024-T86 aluminum alloy skin plus urethane foam-in-place sandwich construction specimens.

c. Edge compressive strength at 500°F and 600°F of 0.016" thick A-70 titanium skin plus urethane foam-in-place sandwich construction.

4.0 Status and Results - Specimens for this test program are being fabricated at the present time.

1.0 Index Code . . . . (Plstc-13,24HCM)(I-i)

2.0 Title - T.R. No. 32A-028.03, Strength Evaluation of Spliced and Unspliced Honeycomb from F-4H Outer Wing Panel (S/N 28)

3.0 Objective - X-Rays of S/N 28 outer wing panel exhibited core splices in -79 honeycomb core. The objective of this test program is to determine if specimens with core splices possess adequate transverse and longitudinal (bending) shear strength. The scope of this investigation includes the following:

a. Preparation of six transverse shear test specimens (3" x 8") and six longitudinal shear test specimens from the R/H 32-15004 outer wing panel honeycomb section. Nine of these twelve specimens contained a splice determined by X-Ray.

b. Shear strength at room temperature for both spliced and continuous-core specimens.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. A comparison of shear strengths of spliced and continuous-core specimens showed no difference in strength.

1.0 Index Code . . . . (Plstc-6HCM)(I-b,k)

2.0 Title - 32A-028.04 Mechanical Testing at Temperature of Failed Honeycomb Panels from S/N 210, 206, 94 and 57.

3.0 Objective - To determine peel, short column compression and flatwise tension strengths at elevated temperature of specimens removed from honeycomb assemblies which failed in flight.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. A tabulated summary of test results obtained is presented below.

Type of Test	Test Panels from			
	S/N 94	S/N 57	S/N 206	S/N 210
Flatwise Tension Strength (psi)	808 at R.T. 520 at 225°F 504 at 250°F 43.75 at 350°F	376 at R.T. 187.5 at 225°F 49.5 at 250°F	523 at R.T. 260.7 at 225°F 134.8 at 250°F	430 at R.T. 202.5 at 225°F 79.0 at 250°F
Peel Strength (in-lbs Torque/in width)	33.1 at R.T. 39.9 at 250°F	30.7 at R.T. 22.8 at 250°F	28.3 at R.T. 31.1 at 250°F	21.7 at R.T. 28.0 at 250°F
Short Column Compression Strength (psi)	23,094 at 350°F	36,040 at 250°F	39,150 at 250°F	30,400 at 250°F

1.0 Index Code . . . . (Plstc-6CC)(II-d)

2.0 Title - 32A-028.05, Evaluation of Materials Presently Used to Repair Damaged Aluminum Honeycomb

3.0 Objective - To determine percent volatiles given off by plastic adhesives presently being used to repair damaged aluminum honeycomb aircraft structures. The scope of this investigation includes the following:

a. Preparation of 6 mold samples of Epon 828 using curing agent D manufactured by Shell Chemical Company.

b. Preparation of 6 mold samples of Epon 828 using catalyst D.T.A. (Diethylene Triamine) manufactured by Fisher Scientific Company.

c. Enclose each mold sample in capped chamber and expose to temperature cycles of 175°F for 2 hours and 275°F for 30 minutes.

d. Determination of loss in weight of 6 mold specimens after heating to 175°F. Also weight loss for 6 mold specimens after heating to 275°F.

e. Determination of maximum pressure developed at temperature and pressure after cool down on 6 mold specimens heated to 175°F. Also, pressure data for 6 mold specimens heated to 275°F.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. Weight loss of the repair epoxy material during curing and exposure to elevated temperatures were inconsistent. Some samples indicated an increase in weight, some showed a loss. Pressure increases during curing and heat exposure were no greater than the pressure increases provided by air of equal volume.

1.0 Index Code . . . . (Plstc-6HCM)(I-b, k)

2.0 Title - T.R. No. 32-028.13 Mechanical Testing, At Room And Elevated Temperatures, Of Failed Honeycomb Panel From F4H S/N 220 Outer Wing

3.0 Objective - To perform peel, short column compression and flatwise tension tests at 250°F and room temperature on outer wing panel from F4H S/N 220 which failed in flight. Also to conduct "chromatographic" analysis on gases given off inside honeycomb specimen when heated to 250°F.

4.0 Status and Results - All testing, except the chromatographic gas analysis of gases given off inside honeycomb specimen at elevated temperatures has been completed. A tabulated summary of all mechanical property test results is presented below.

Type of Test	Results
Peel at Room Temperature	16.8 in. lbs. Torque/in. width
Peel at 250°F	23.5 in. lbs. Torque/in. width
Flatwise Tension at Room Temp.	453.0 psi
Flatwise Tension at 225°F	183.1 psi
Flatwise Tension at 250°F	57.0 psi
Short Column Compression at R.T.	38,000 psi
Short Column Compression at 225°F	56,400 psi
Short Column Compression at 250°F	36,000 psi

1.0 Index Code . . . . (Plstc-13A, HCM)(I-k)

2.0 Title - T.R. No. 32-028.15, Effects of Air Pressure Checks on Core Node Bonds of Aluminum Honeycomb Assemblies.

3.0 Objective - M.A.C. Process Specification 11240 requires air pressure checks on honeycomb panels under water (for all honeycomb panels containing perforated core) to determine if these panels are properly sealed. The air is to be injected into the honeycomb panels at a rate which will provide a pressure increase at inlet of 1 psig per minute up to a maximum pressure of 12 psig. A question arises as to whether this injection rate can cause possible node bond damage to the aluminum honeycomb core. The objective of this test program is to determine what effects air pressure checks will have on core node bonds of assemblies containing perforated aluminum honeycomb.

4.0 Status and Results - This test program has been completed and the laboratory report is being written. Test results indicate that air pressures of 12 psi applied instantaneously will not damage core node bonds in perforated aluminum honeycomb assemblies.

1.0 Index Code . . . . (Plstc-13A,24A)(I-k)

2.0 Title - T.R. No. 32A-028.16, Determination of Initial Values for Flatwise Tension Tests on Honeycomb Panels.

3.0 Objective - To determine initial flatwise tension strength of honeycomb panels bonded with FM-47 adhesive and to determine what effect flight conditions have on the flatwise tension strength. The scope of this investigation includes the following:

a. Prepare thirty flatwise tension specimens (3.00" x 3.00" x thickness) from aileron panel. Bond 1.00" x 3.00" x 3.00" aluminum tension pads to all specimens.

b. Determine flatwise tension strength at room temperature of specimens that have been exposed to various heat and heat-vacuum cycles of 250°F for 10 minute and 30 minute intervals at pressure of 22.5 inches of mercury.

4.0 Status and Results - This test program is partially completed. Test results obtained thus far are presented below.

a. The average flatwise tension failing stress at room temperature for all fifteen test specimens was 547 psi.

b. Flight conditions (temperature and pressure) have no effect on flatwise tension strength when tested at room temperature.

1.0 Index Code . . . . (Plstc-6HCM)(I-b,k)

2.0 Title - T.R. No. 32A-028.17, Room and Elevated Temperature Mechanical Properties of Nonperforated Honeycomb Stabilator Panel No. 12 Bonded With FM-61.

3.0 Objective - To obtain peel, short column compression and flatwise tension strength data at room temperature, 250°F and 350°F of stabilator test panel No. 12 (nonperforated honeycomb core) bonded with FM-61 epoxy adhesive. The scope of this investigation includes the following:

a. Peel strength at room temperature, 250°F and 350°F.

b. Short column compression strength at room temperature, 250°F and 350°F.

c. Flatwise tension strength at room temperature, 250°F and 350°F.

d. Report types of failures in all tests, e.g., percent cohesion, percent adhesion failures.

4.0 Status and Results - All test specimens have been fabricated and are ready for mechanical testing.

1.0 Index Code . . . . (Plstc-13+24A)(I-k)

2.0 Title - T.R. No. 32A-028.18, Correlation of Fokker Bond Tester Values With Flatwise Tension Values of Outer Wing Honeycomb Panel from S/N 41.

3.0 Objective - The outer wing panel from F4H S/N 41 developed a blister in flight. The remains of this honeycomb panel was cut into 3.0 inch squares which were checked using the Fokker Bond Tester. The objective of this test program is to obtain flatwise tension strength values for these same 3 inch specimens so that a correlation can be made between the Fokker Bond Tester readings and the flatwise tension strength results. The scope of this investigation includes the following:

a. Flatwise tension strength determinations at room temperature and 180°F.

b. If failure occurs in the skin-to-core bonds, report whether failures occurred on the bottom or top surfaces of the flatwise tension specimens.

4.0 Status and Results - This test program has just been initiated.

1.0 Index Code . . . . (Plstc-13RL,Cer-10)(I-k)(II-b)(V-d)

2.0 Title - T.R. No. 513-344, Structural, Ablative and Density Evaluation - MX2625 Molded at Various Pressures.

3.0 Objective - MX2625, manufactured by Fiberite Corporation, is essentially chopped silica fibers impregnated with phenolic resin. The recommended pressure for molding parts from this material is 2000 psi. Such high pressure requires high strength, complicated, expensive tooling to produce a molded part. The objective of this test program is to determine if the high molding pressure recommended for MX2625 molding material can be reduced and still produce good mechanical and ablative properties. The scope of this investigation includes the following:

a. Fabrication of MX 2625 test panels at molding pressures of 350, 500, 750, 1000, and 1600 psi.

b. Determination of tensile properties at room temperature, 500°F and 700°F of test specimens prepared from test panels molded at various pressures mentioned in Paragraph 3.0(a) above.

c. Determination of modulus of elasticity at room temperature, 500°F and 700°F of test specimens, prepared from molded test panels mentioned in Paragraph 3.0(a) above.

d. Determinations of density and weight of each ablation disk and weight of each ablation specimen.

e. Calculation of the effective heat of ablation by dividing the heat dissipated by the specimen weight loss.

f. Description and photographs of failed test specimens and test set-ups.

g. Plots of typical stress-strain curves at room temperature, 500°F and 700°F.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. A tabulated summary of test results obtained is presented below.

a. Tensile Properties Data

Molding Pressure (psi)	Average Ultimate Strength at Test Temperature (psi)		
	Room Temperature	500°F	700°F
1550	8,081	2756	2070
1000	8,018	2762	2142
750	6,651	2338	1992
500	4,342	1834	1441
350	4,220	1640	1370

The average room temperature ultimate strength from a wedge molded at 2000 psi pressure was 4,990 psi.

b. Ablative Test Results*

Molding Pressure (psi)	Density (lb/ft^3)	Effective Heat of Ablation (BTU/lb)
1550	110.0	12,240
1000	111.7	12,630
750	110.7	11,650
500	109.2	10,610
350	108.8	10,580

*Each specimen was exposed for 120 minutes to an air-arc plasma jet with a heat flux of 55 $Btu/ft^2/sec$.

c. The results of tensile, density and ablative tests indicate that these properties decrease at molding pressures below 1000 psi.

1.0 Index Code . . . . (Plstc-12,16)(SCd-11)

2.0 Title - T.R. No. 45-640, Particle Contamination Count of Standard Polyethylene Bags and Polyethylene and Nylon Bags Produced Under Clean Room Conditions.

3.0 Objective - Valves used in the spacecraft environmental control systems have been found to be contaminated. Analyses of the contaminant indicates the presence of plastic particles which are believed to have come from the polyethylene bags used to protect the valves from contamination. The objective of this test program is to determine the relative cleanliness of nylon and polyethylene bags manufactured under clean room conditions and polyethylene bags currently available at M.A.C. The scope of this investigation includes the following:

a. Preparation of particle free distilled water utilizing millipore filtration technique.

b. Contaminant extractions from each set of clean room fabricated nylon and polyethylene and standard polyethylene bags that have been purged with particle free distilled water.

c. Filtration of the contaminant extracted solutions utilizing vacuum filtration techniques.

d. Microscopic particle count of the number of particles on the filter grid for contaminant extracted from each bag. Record micron particle sizes of 10-25, 25-50, 50-100, 100-500 and over 500.

e. Determination of total particle count of micron size obtained from analysis of contaminant extracted from each bag.

f. Photographs of equipment set-up and photomicrographs of filter discs which contain measured contaminant particles.

4.0 Status and Results - This test program has just been initiated.

1.0 Index Code . . . . (Rub-11)(I-k)(II-i)(IV-f)(V-i)

2.0 Title - T.R. No. 32A-067.01, Qualification of The Compact Wire Bundle Concept For Continuous (1000 Hours) Operation at 300°F.

3.0 Objective - From the beginning of the Compact Wire Bundle (CWB) test program self-bonding, triangular guide line (TGL) silicone tape has been used in fabricating the protective boots for the wire bundles used in the F4H-1 airplane. This tape exhibits the following undesirable properties: moderate-to-poor resistance to attack by solvents, swelling, loss of self-bonding quality, loss of tensile strength, and shrinkage due to heat exposure. It is necessary to obtain data by testing several brands of silicone triangular guide line tape to determine which tape will best withstand exposure to heat and solvents such as JP-4 fuel, Mozel No. 18 solvent and hydraulic fluid. The objective of this test program is to qualify silicone tape for 300°F continuous operation (1000 hours) in compact wire bundles. The scope of this investigation includes the following:

a. Preparation of thirty-six test specimens, 12 from each of the following brands:

   1. Flexite T.G.L. tape.

   2. Permacel ES5298 tape.

   3. Moxness MS70T09-5 tape.

   Each specimen will consist of two 5.50 inch long strips of tape, pressed back-to-back.

b. Tensile properties at room temperature of Flexite, Permacel and Moxness tape specimens before and after exposure to 300°F for 1000 hours.

c. Determination of weight of each tape specimen before and after exposure to 300°F for 1000 hours.

d. Determination of weight and thickness of each tape specimen before and after solvent immersion in JP-4 fuel, Mozel No. 18 solvent and MIL-H-5606 hydraulic fluid for 4 hours. Any deterioration such as swelling, loss of bonding quality or color change will also be reported for each tape specimen after solvent immersion test.

e. Tensile properties at room temperature of each tape specimen after solvent immersion test.

4.0 Status and Results - This test program has just been initiated.

1. MATERIAL CLASSIFICATION: Composite Electrically Conductive Adhesives

2. TITLE: Electrical Resistance and Lap Shear Strength Tests on Silver Filled Conductive Adhesives

3. OBJECTIVE: A limited evaluation was conducted to determine the electrical resistance and lap shear strength of selected silver filled conductive epoxy resin adhesives. Electrical resistivity was determined in accordance with ASTM B193 and lap shear values were obtained at -67 F, 75 F, and 165 F after 10 minutes exposure to the test temperature.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The electrical resistance of the silver filled adhesives is as follows:

Adhesive		Resistance in ohms/inch Average Values
Epon 820 Curing Agent U V-9 Conductive Silver Powder	16 pbw 4 pbw 80 pbw	1.70
Aerobond 2015		1.135
Eccobond 56C		0.0056
Eccobond 58C		0.029

The lap shear values are presented as follows:

Adhesive		Lap Shear Strength in PSI-Average Values		
		-67 F	75 F	165 F
Epon 820 Curing Agent U V-9 Conductive Silver Powder	16 pbw 4 pbw 80 pbw	1320	1230	1233
Aerobond 2015		1390	1460	1370
Eccobond 56C		840	630	1150
Eccobond 58C		1330	940	1740

This work was sponsored by Autonetics.

Index No. 366

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: High Temperature Organic Structural Adhesives; Development

3. OBJECTIVE:

Screening tests were conducted at 550F on experimental Epoxy Novalac modified silicone phenolic formulations to determine the possibility of using adhesive bonded structures at elevated temperatures.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The following values were obtained at 550F after exposure to 600F for noted periods of time.

Exposure Time @ 600F	Failing Load @ 550F	% of Original Strength
0	1255	-
24	710	57%
48	680	55%
96	560	45%
216	440	36%

The above determinations were made using a sandwich flexural test on a 6 inch span. The specimen configuration was: (1) .025 17-7PH heat treated to 1050C facings, (2) 1/4, .002 17-7PH heat treated to 1050C perforated hexcel honeycomb. All specimens were stabilized at test temperature for 30 minutes prior to testing. Additional tests will be conducted on improved formulations of this type of adhesive. Test data from the supplier, Narmco Industries, indicates that Metlbond 316 is more stable and adaptable to honeycomb bonding than previously tested formulations.

This work was Company-sponsored by the Columbus Division, and the program was limited in size.

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: Adhesive Properties of a Polysulfide Elastomer

3. OBJECTIVE: A limited evaluation was conducted to determine the adhesive properties of EC-1675 polysulfide elastomer as supplied by Minnesota Mining and Manufacturing surfaces of aluminum, copper, stainless steel, and epoxy resin-fiberglass laminates. Physical properties of the cured elastomer were also obtained.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

The physical properties data for EC-1675 are presented as follows:

Specific Gravity	1.5
Solids Content	98.6 percent
Tensile Strength	240 PSI
Tear Strength	70 PSI
Elongation	300 percent
Shore A, Hardness	
Cure 1 Week at	
Room Temperature	50
167 F	55
200 F	60
260 F	60

The lap shear values obtained are as follows:

Bonded Surfaces	Lap Shear (PSI) Cure 72 Hours at Room Temperature and 4 Hours at 167 F	Lap Shear (PSI) Aged for 7 Days at 260 F	Lap Shear (PSI) After Thermal Shock 167 F to -65 F
Aluminum	240	198	220
Stainless Steel	190	135	211
Copper	220	120	240
Epoxy Glass Laminate	180	110	350

This work was sponsored by Autonetics.

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: Adhesive Bonding of SE 555 (General Electric Co.) Silicone Rubber to Aluminum

3. OBJECTIVE: A moderate evaluation was conducted to determine if silicone RTV compounds could be used to bond SE 555 to aluminum. Lap shear strength values and peel strength values were obtained using test samples prepared using primer coatings on the aluminum and various surface treatments for the SE 555.

4. ABSTRACT OF RESULTS OR CONCLUSIONS:

Lap Shear Strength Tested at 75 ± 5 F on 2024 Alclad

Adhesive	Shear Strength *PSI	Bond Thickness In.	Primer	Type Failure
EC 1691 10 Parts A/100 Parts B	219	.063	EC 1967	100% Cohesive
RTV 88	233	.053 - .058	SS 4004 Lot 143	85% Cohesive
RTV 90	405	.03	SS 4004 Lot 143	60% Cohesive
RTV 90	242	.024	SS 4004 Lot 143	94% Adhesive RTV to Primer
RTV 88	500	.010	SS 4004 Lot 137	100% Cohesive
RTV 90	715	.010	SS 4004 Lot 137	100% Cohesive

*Average of four specimens

Peel Strength Tested at 75 ± 5 F

Adhesive	SE 555 Treatment	Peel Strength** lbs/in - width	Bond Thickness in	Primer for Alclad	Type Failure
EC 1691	Isopropanol	1.1	0.063	EC 1967	Adhesive, SE 555 Inhibit Cure
RTV 88	Isopropanol	2.6	0.054	SS 4004	Adhesive, SE 555 to RTV
RTV 90	Isopropanol	8.2	0.05	SS 4004	Adhesive, SE 555 to RTV
RTV 88	Q3-0121	4.5	0.052	SS 4004	Adhesive, Q3-0121 to RTV
RTV 90	Q3-0121	16.3	0.064	SS 4004	Adhesive & Cohesive Q3-0121 to RTV
RTV 90	Isopropanol	4.3	0.0216	SS 4004	75% Adhesive RTV to Primer
RTV 90	Q3-0121 .007 inch film	3.9	0.0187	SS 4004	100% Adhesive RTV to Primer
RTV 90	J29130 .005 inch film	0.4	0.016	SS 4004	Coating Brittle Adhesive SE 555 to Coating
RTV 90	RTV 60 & T-773 .0067 film	5.5	0.025	SS 4004	Adhesive, SE 555 Appeared to Crack
RTV 88	Isopropanol	0.15	0.0123	SS 4004	Adhesive, RTV to Alclad
RTV 88	Q3-0121 .010 inch film	0.3	0.008	SS 4004	Adhesive, RTV to Alclad
RTV 88	Thermolite T-12	0.06	0.0124	SS 4004	Adhesive, RTV to Alclad
RTV 88	Thermolite T-12 Wipe with Isopropanol	0.8	0.0127	SS 4004	Adhesive, RTV to Alclad
RTV 90	Isopropanol	2.1	0.01	SS 4004	Adhesive SE 555 to RTV
RTV 90	Q3-0121 .009 inch film	8.0	0.0208	SS 4004	Adhesive Q3-0121 to RTV
RTV 90	Thermolite T-12	3.7	0.021	SS 4004	Adhesive SE 555 to RTV
RTV 90	Thermolite T-12 Wipe with Isopropanol	4.5	0.024	SS 4004	Adhesive RTV to SE 555 & Al
RTV 90	220 Varnish	2.7	0.0266	SS 4004	Adhesive SE 555 to Varnish

**Average of three or four specimens, maximum recorded on the Riehle Tensile Tester, jaw separation two inch per minute.

This work was sponsored by Autonetics.

1. MATERIAL CLASSIFICATION: Adhesives

2. TITLE: Determination of Bonding Techniques Using Heat Resistant Epoxy Resins as Repair Adhesives

3. OBJECTIVE: This extensive program, earlier reported in NA-61-1049-1, is continuing with current effort being expended in the determination of the best practical bonding technique using Epoxylite 5302 as a repair adhesive. The effect of bonding and curing techniques on the lap shear strength at temperature and stress-rupture strength at temperature is being evaluated.

4. ABSTRACT OF RESULTS OR CONCLUSIONS: The lap shear strength of Epoxylite 5302 obtained with typical repair configuration (.010" PH 15-7 Mo sheet on 1" total thickness stainless sandwich) is as follows:

Test Temp °F	Shear Strength As Fabricated psi	Shear Strength After 250 Hour Aging At 450 F - psi
450	950	900
500	To be determined	[illegible] be determined

The stress-rupture strength has been estimated as follows:

Test Temp °F	Stress-Rupture Strength in psi for 250 hrs
450	500
500	500

These data show the superiority of Expoxylite 5302 to the previously selected material. This work is being conducted under USAF sponsorship by the Los Angeles Division.

REF: NA-61-1049-1, page A-9

GENERAL MATERIALS INFORMATION - PHASE II
MATERIALS WORK IN PROGRESS

TITLE: High Temperature Adhesive Systems

OBJECTIVE: To develop an adhesive system for joining precipitation hardening corrosion resistant steels for use at temperatures of 450 to 600 F for times up to 1000 hours, and at higher temperatures for shorter periods of time.

RESULTS: Short time tests at 600 F have been performed on eleven materials. Statistical analysis of the results of these preliminary tests has indicated that further testing should be performed on phenolic-base and phenyl-silane-base adhesives. Changes in the chemical nature of the adhesives as a result of the high temperature exposure are being investigated on the spectrophotometer. A unit for performing simultaneous differential thermal analysis and thermal gravimetric analysis on the same sample has been designed and is being constructed.

ESTIMATED COMPLETION DATE: 15 July 1962

DATA SOURCE: Northrop Corp., Norair Div. (76823)

MATERIALS RESEARCH PROJECT SUMMARY

GDA

Period: January 1962 to 1 March 1962

Material Classification: Adhesives and Lubricants

Materials: Selection open

Title: Adhesion and Lubrication in Space Environment

Project No: REA 111-9305

Objective:

1) To study the surface and structural variables of a metal that control the adhesion characteristics in a high vacuum.

2) To determine adequate lubrication systems to be used in a high vacuum system.

Current Status:

The design of apparatus for the adhesion and lubrication experiments is underway. Both pieces of equipment will be designed to eliminate de-gassing problems so that hard vacuums can be achieved.

The lubrication test system will incorporate a magnetic clutch drive so that only the test bearing will be exposed to the vacuum. To insure long-time service, the drive motor will be encapsulated so that its bearings will be maintained in an atmosphere.

1.0 Index Code . . . . (Be-Plstc-6A)(I-i)
(Be-Plstc-6,13A)(I-i)

2.0 Title - T.R. No. 52-051.03.02, Ablation Shield Development Testing: Adhesive Evaluation and Elevated Temperature Properties.

3.0 Objective - The purpose of this phase of the advanced Mercury ablation shield development program is to evaluate several high temperature adhesives and to determine their short time elevated temperature shear properties. The scope of this test program includes the following:

a. Surface preparation of finger panels of Brush Beryllium Company's QMV-200-A press sintered block by the combined liquid honing and alkaline cleaning method.

b. Bond the above panels with HT424, EC1639 plus AF107, and Aerobond 430 adhesives.

c. Determine lap shear strength of bonded specimens at room temperature, 500°F, 650°F, and 800°F.

d. Visual examination of failed specimens.

4.0 Status and Results - The test work has been completed and the laboratory report is being prepared. Test results indicate that joints produced with HT424 adhesive developed the highest shear strength at 650°F and 800°F.

1.0 Index Code . . . . (Plstc-2A)(I-i)(IV-e)

2.0 Title - T.R. No. 513-298, Determination of the Reliability of Eastman 910 Adhesive.

3.0 Objective - The easy handling and fast curing characteristics of Eastman 910 adhesive, make it ideal for quick setup and repair jobs. The objectives of this test program are to determine the strength and thermal stability of this adhesive before and after exposure to environments such as heat, high humidity, distilled water, fuel, and oil. The scope of this evaluation includes the following:

a. Lap shear strength of exposed and unexposed cemented joint specimens at room temperature, 180°F and 225°F.

b. Determination of any chemical attack or physical breakdown in the cemented joints.

4.0 Status and Results - Flat sheet metal, finger type cemented lap shear specimens have been tested. Test results indicate the following:

a. The failing stress of 2024-T3 bare aluminum lap shear specimens bonded with Eastman 910 adhesive, using fabrication and testing conditions specified for this test program, is unpredictable.

b. Water, high humidity and elevated temperature adversely affect the strength of Eastman 910 adhesive.

c. JP-4 fuel, jet engine oil and hydraulic oil do not adversely affect strength of Eastman 910 adhesive.

d. Alodined aluminum surfaces are not compatible with Eastman 910 adhesive.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

ADHESIVES; BONDING; BERYLLIUM COMPONENTS

DESCRIPTIVE TITLE:

Process Development for the Adhesive Bonding of Beryllium

OBJECTIVE:

The establishment and verification of a process for the fabrication of adhesive bonded beryllium structural components.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Beryllium offers a potential weight saving advantage over other materials for use at elevated temperatures provided efficient methods of attachment and fabrication can be established.

Preliminary results indicate that conventional high-temperature resistant adhesives will provide adequate lap-shear strength when bonding beryllium to aluminum.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

ADHESIVE; EPOXY-POLYAMIDE; HONEYCOMB BONDING

DESCRIPTIVE TITLE:

Evaluation of Lightweight Structural Adhesives for Honeycomb Bonding

OBJECTIVE:

To develop a procedure for the fabrication of structural honeycomb assemblies utilizing non-perforated core with lightweight adhesives at vacuum bonding pressures.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Narmco Metlbond 406 and Bloomingdale Rubber FM-1000 adhesives were evaluated. The latter adhesive was found to be more suitable for Vertol's application since available heating equipment could not satisfy the heat-up-rates required for the Metlbond 406 system. Flat and simple curvature sandwiches with non-perforated core are being bonded successfully in production with FM-1000 adhesive and at vacuum bonding pressures. Results on aluminum-to-aluminum 1/2" lap shear and 3" T-peel were in the neighborhood of 6000 psi and 200 lbs./3" width, respectively.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

ADHESIVE; METLBOND 406; PRELIMINARY EVALUATION

DESCRIPTIVE TITLE:

Preliminary Evaluation of Metlbond 406 Adhesive

OBJECTIVE:

To check the basic strength properties of Metlbond 406 adhesive in metal-to-metal and honeycomb sandwich bonds.

ABSTRACT OF RESULTS AND CONCLUSIONS:

1. Lap joint shear strength of ten (10) specimens averaged 6220 psi at 75°F. When tested at 250°F, the average of 10 specimens was 4100 psi.

2. After the 30 day salt spray, the bonds retained 76% of the control strength. Thirty (30) days exposure in condensing humidity reduced lap shear strength to 56% of control.

3. Facing to honeycomb core bonds exhibited good dry strength. The climbing peel strength was 40 in-lb per 3 inch width.

4. Details are reported in Wichita Job Report AP-2-103.

Index No. 377

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION:

ADHESIVE; NITRILE-PHENOLIC; ROTOR BLADE BOXES

DESCRIPTIVE TITLE:

Disposition of Over-Age Rotor Blade Boxes

OBJECTIVE:

To develop a procedure for the rejuvenation of rotor blade boxes which were stored for a period in excess of the presently specified 120 days.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The present requirement for the use of Narmco 4021 adhesive primed rotor blade boxes within 120 days was based upon the results of a previous investigation. The group of boxes in question (over 100) was stored for periods up to 142 days and were therefore subject to rejection.

Representative boxes were given a "rejuvenation treatment" which consisted of immersing the pertinent surfaces, to be bonded subsequently, in acetone and repriming. Bonding strength determinations after this treatment indicated that these discrepant boxes could be reclaimed in this manner.

Details are reported in Vertol MLR No. 607-119, dated 11/11/60.

MATERIAL CLASSIFICATION:

ADHESIVES; SHELL 422; RESISTANCE TO HEF

DESCRIPTIVE TITLE:

Resistance of Shell 422 Type Structural Adhesive to High Energy Fuel (HEF)

OBJECTIVE:

To determine the effect of immersion in HEF on the high temperature strength of Shell 422 type adhesive bonds.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Fifteen aluminum panel assemblies were bonded with Bloomingdale HT-424 adhesive and cut into 1.00 inch wide specimens. A random arrangement of the specimens was made and 15 specimens were exposed to each of the following conditions:

(1) No exposure - control specimens
(2) Immersion in HEF for 24 hours at 300°F
(3) Immersion in HEF for 30 days at room temperature
(4) Immersion in HEF for 233 days at room temperature

Each group of 15 specimens was divided into 3 sets of 5 specimens for testing at 250, 350 and 450°F respectively.

The shear strength at 450°F was unaffected by immersion in HEF at room temperature for periods up to 233 days.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION·

ADHESIVE, EPON 910; ENVIRONMENTAL EFFECTS

DESCRIPTIVE TITLE:

Environmental Tests on Eastman 910 Adhesive

OBJECTIVE:

To determine the effects of different environments on Eastman 910 Adhesive.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Eastman 910 is permanently damaged by exposures to water at ordinary temperatures, salt spray and extremes of weather.

The bond strength of Eastman 910 is not affected by sustained temperatures of -65°F.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, EPON 901; PROPERTIES EVALUATION

DESCRIPTIVE TITLE:

Testing of Epon 901

OBJECTIVE:

To determine environmental and high temperature properties of the three grades of Epon 901, when applied over solvent cleaned and chemically cleaned surfaces.

ABSTRACT OF RESULTS AND CONCLUSIONS:

All three grades of Epon 901 offered good resistance to the different environmental exposures, except through salt spray on the solvent cleaned specimens.

Intermittant service temperatures as high as 400°F can be tolerated with any of the three grades as long as the bond is not carrying a load. The maximum operating temperature for Epon 901B-1 and B-2 should be limited to 200°F, and Epon 901-B3 bonds should be limited to 300°F when the bonds are stressed. These operating temperatures are based on specimens where the surfaces were chemically cleaned.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, EPOXY-PHENOLIC, STRUCTURAL, HIGH TEMPERATURE

DESCRIPTIVE TITLE:

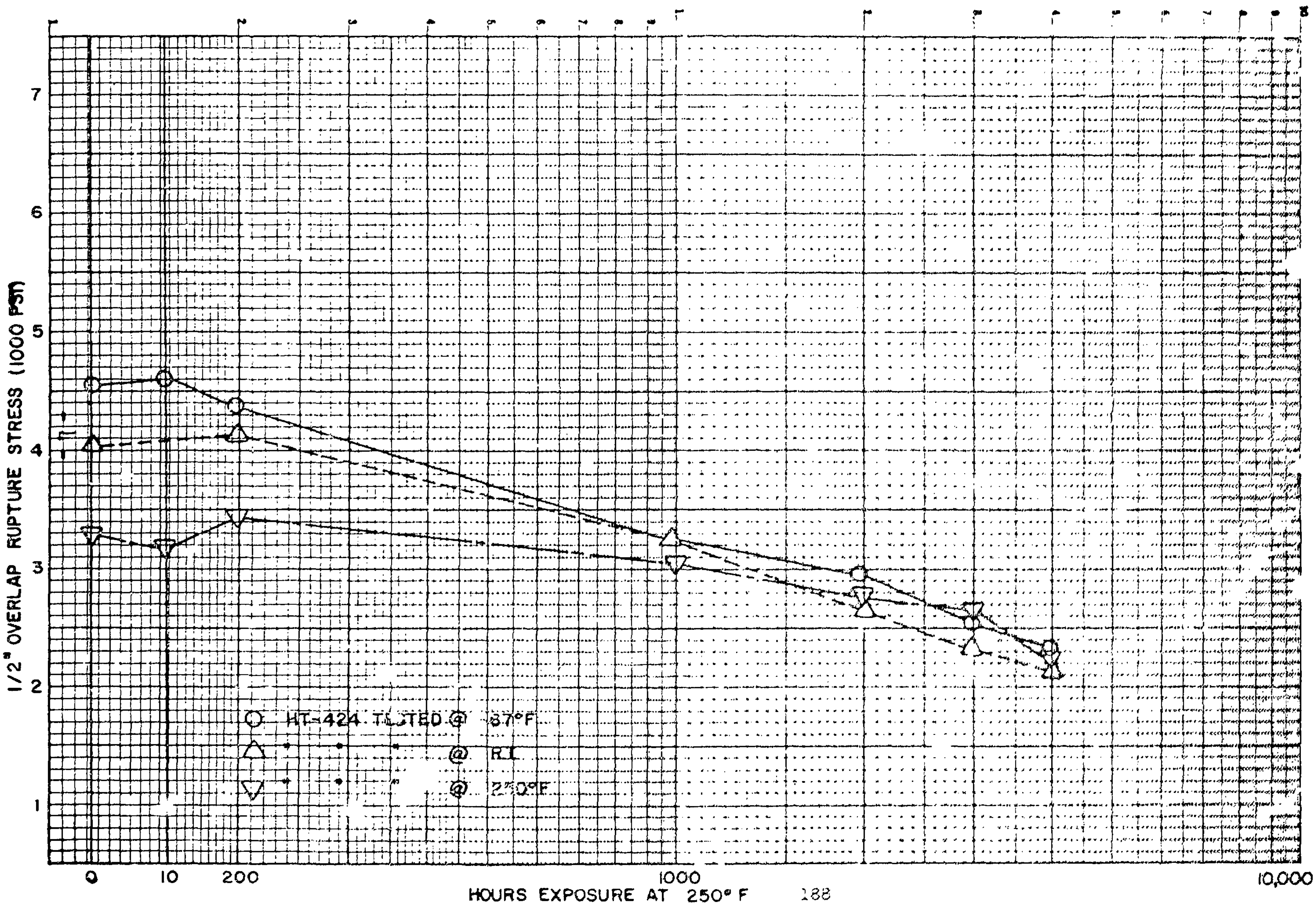
Determination of Some Engineering Properties of HT 424 Adhesive

OBJECTIVE:

To determine selected mechanical properties of HT 424 adhesive after exposure periods to temperatures up to 250°F.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The table below shows the effect of dry heat exposure (250°F) at sea level atmosphere. The adhesive is Bloomingdale Rubber Company, Designation HT 424.


1/2" OVERLAP RUPTURE STRESS (1000 PSI)
HT-424 TESTED @ 87°F
@ RT
@ 250°F
HOURS EXPOSURE AT 250° F

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, HONEYCOMB SANDWICH STRUCTURE; CORE SHEAR STRENGTH STUDY

DESCRIPTIVE TITLE:

Effect of Sandwich Variables on Bonded Aluminum Honeycomb Core Shear Strength

OBJECTIVE: To determine the effect of variations in facing thickness, core thickness and span length on honeycomb core shear strength in bonded aluminum sandwich.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Span length, core thickness, and facing thickness have definite effects on apparent core shear strength. These effects are shown generally to be as follows:

a. Increasing the span length between 6 and 16 inches decreases the apparent core shear strength.
b. Increasing the facing thickness between .010 and .071 inch increases the apparent core shear strength.
c. Increasing the core thickness between .290 and .960 inch decreases the apparent core shear strength.

A larger percentage of skin buckling (or failure other than core shear failure) occurs with a single mid-span loading than with a double mid-span loading. Generally, skin buckling occurs with either type of loading when long spans, thin facings and/or thick cores are used.

Average transverse shear strength is 64 ± 4% of longitudinal shear strength.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, METLBOND 406, STRUCTURAL; PRELIMINARY EVALUATION

DESCRIPTIVE TITLE:

Evaluation of Metlbond 406 Adhesive

OBJECTIVE:

The objective of this program was to conduct a preliminary evaluation of the basic strength properties of Metlbond 406 Adhesive

ABSTRACT OF RESULTS AND CONCLUSIONS:

Initial lap shear strengths of 5000 to 6000 psi were obtained on aluminum. Strengths deteriorated to about 2700 psi after 16 to 24 weeks exposure to condensing humidity. Salt spray specimens deteriorated to zero strength after 12 weeks exposure. Room temperature peel strengths (climbing drum method) averaged 75 in-lb/inch width on aluminum to aluminum bonds.

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, PHENOLIC-ELASTOMER, STRUCTURAL

DESCRIPTIVE TITLE:

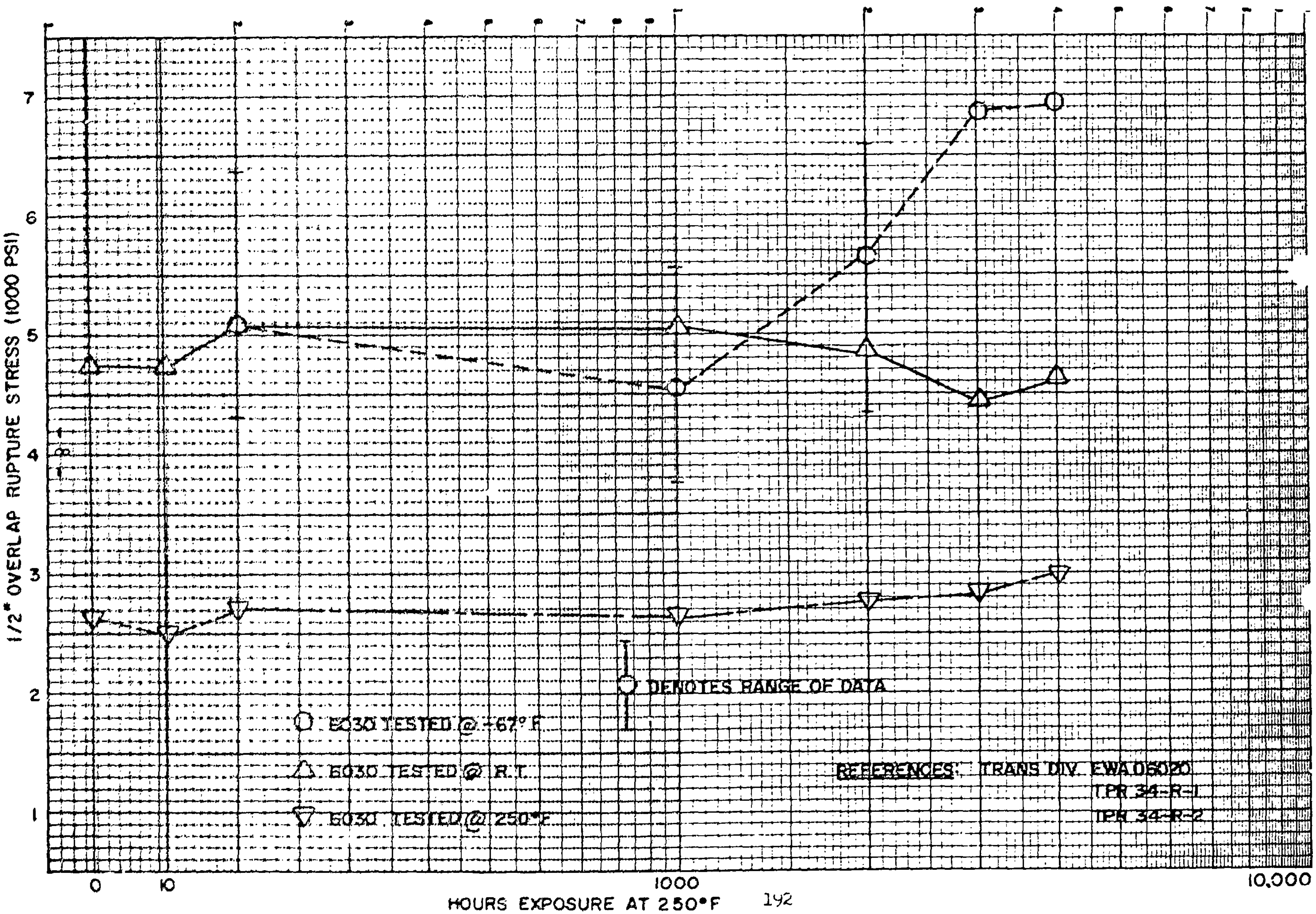
Determination of Some Engineering Properties of AF 6030 Adhesive.

OBJECTIVE:

To determine selected mechanical properties of AF 6030 adhesive after extended time periods at 250°F.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The attached figure shows the effect of dry heat exposure (250°F) at sea level atmosphere. The adhesive is Minnesota Mining and Manufacturing Company, Designation AF 6030.



1/2" OVERLAP RUPTURE STRESS (1000 PSI)
7
6
5
4
3
2
1
0
10
1000
10,000
HOURS EXPOSURE AT 250°F
DENOTES RANGE OF DATA
E030 TESTED @ -67° F
E030 TESTED @ R.T.
E030 TESTED @ 250°F
REFERENCES: TRANS DIV. EWA 06020
TPR 34-R-1
TPR 34-R-2

31 Aug 61

MATERIAL CLASSIFICATION:

ADHESIVE, TAPE, PRESSURE SENSITIVE; ELEVATED TEMPERATURE EVALUATION

DESCRIPTIVE TITLE:

Investigation of Pressure Sensitive Tapes for High Temperature (300 - 800°F). Application

OBJECTIVE:

Establish design data and criteria for property characteristics of feasible tapes for use in 300 - 800°F. temperature ranges.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Pressure sensitive tape from 3M, Permacel, and Connecticut Hard Rubber were screened for possible application at elevated temperatures.

Tapes selected were treated paper, glass, Teflon, and aluminum.

The tapes tested were selected to fit definite temperature ranges as follows:

Paper	Maximum	350°F
Aluminum	Maximum	600°F
Glass	Maximum	575°F
Teflon	Maximum	550°F

Complete results and conclusions are available in Test Document T5-1945 "Investigation of Pressure Sensitive Tapes for High Temperature (300 - 800°F) Aero-Space Applications".

GENERAL MATERIALS INFORMATION - PHASE II
MATERIALS WORK IN PROGRESS

TITLE: High Temperature Adhesive Systems

OBJECTIVE: To develop an adhesive system for joining precipitation hardening corrosion resistant steels for use at temperatures of 450 to 600 F for times up to 1000 hours, and at higher temperatures for shorter periods of time.

RESULTS: Short time tests at 600 F have been performed on eleven materials. Statistical analysis of the results of these preliminary tests has indicated that further testing should be performed on phenolic base and phenyl-silane base adhesives.

Spectrophotometer studies of the degradation mechanism of a phenolic base and a phenyl-silane base adhesive on steel have been carried out on samples aged in air at 600 F for 48 hours. The techniques developed seem to be quite satisfactory and the data will be correlated with samples aged in a nitrogen atmosphere and in a vacuum to fully establish basic conditions.

Spectrographic techniques of determining quantitative iron absorption in the bondline are being developed. Spectrographic standards are being developed and procedures for processing samples are being worked out. At present, bondlines are being analyzed in total thickness, whereas, a correlation of iron absorption with thicness is needed, and is being accomplished.

The differential thermal analysis unit is completed and is operating satisfactorily. Thermal stability measurements have been made on a phenolic base and a phenyl-silane base adhesive. Basic operating parameters of the instrument have been established.

ESTIMATED COMPLETION DATE: 15 July 1962.

DATA SOURCE: Northrop Corp., Norair Div. (76823)

TR 50-2019 (Corporate Funded) 1 of 2

TITLE Effect of 700°F and Vacuum on Properties of Systems and Safety Materials

OBJECTIVE Determine change in properties of selected materials as a function of time at 700°F and pressures of 10^{-1}mm Hg to 10^{-6} mm Hg.

DISCUSSION Work will provide information on materials under extreme conditions for support of future projects. Materials to be tested are:

(1) Dynabond 132 adhesive (General Dynamics developed structural adhesive)

(2) RTV silicone rubber - X-3-0902 - Dow Corning Corp.,

(3) Narmco Metlbond 316 (Previously identified as X-278) Narmco Materials Division, Costa Mesa, California

Adhesives will be tested in shear using MIL-A-005090D over-lap shear specimens and procedures except adherends will be RS-140 annealed titanium. The RTV will be tested for adhesion using ASTM D 429-58 butt tension specimens except rubber thickness will be .12 to .25 inch. Adherends will be RS-140 annealed titanium.

At least 5 specimens of each material will be tested at room temperature after exposure to each of the following conditions

(1) Temperature; 700°F
(2) Time; immediately after reaching 700°F and after 0.1 hour, 5 hours, and 10 hours at 700°F.
(3) Pressure, ambient, 10^{-1} mm Hg, 10^{-3}mm Hg and 10^{-6} mm Hg.

Adherends will be cleaned as follows:

(1) hand wipe with methyl-ethyl-ketone
(2) Trichloroethylene vapor degrease
(3) Pickle for 30 seconds in room temperature water solution of Nitric acid (15% by volume of 70% HNO_3 solution) and Hydrofluoric acid (3% by volume of 50% HF solution).
(4) rinse in tap water at room temperature
(5) rinse for two minutes in room temperature water solution of trisodium phosphate (50 gms/liter of solution) sodium fluoride (8.9 gms/liter of solution) Hydrofluoric acid -50% solution (26 milliliters/liter of solution).

?-50-2019 (Continued)

(6) rinse in room temperature tap water.
(7) soak in 150°F tap water for 15 minutes.
(8) spray with distilled water and air dry.

Adhesives will be applied and cured 2 hours at 350°F under 50 psi. The RTV will be applied and cured 7 days at room temperature under contact pressure.

RESULTS: See Table I.

TABLE I

Material	Exposure Time, Hrs.	EXPOSURE				
		Control Room Temp. No Vacuum	No Vacuum 700°F	10^{-1} in. Hg 700°F	10^{-3} in. Hg 700°F	10^{-5} in. Hg 700°F
Dyna-bond 132		2199				
	0.1		1178	858	1163	1229
	5.0		638	270	777	583
	10.0		356	329	773	591
Metlbond 316		1729				
	0.1		1573	1076	1460	1256
	5.0		899	513	635	607
	10.0		937	300	532	595
X-3-0902		177				
	0.1		21	14	21	26
	5.0		7	20	25	17
	10.0		3	10	17	17

NOTE: (1) All tests were conducted at Room Temperature after above exposures.

(2) All test results are in pounds per square inch.

ESTIMATED COMPLETION DATE: December 1962

1.0 Index Code . . . . (Be-Plstc-6, 13A)(I-i)(V-h)

2.0 Title - 52-051.03.01, Ablation Shield Development Testing - Surface Preparation of Beryllium for Adhesive Bonding.

3.0 Objective - The purpose of this phase of the ablation shield development program is to evaluate several methods of surface preparation of beryllium for adhesive bonding. The scope of this test program includes the following:

a. Surface preparation of finger panels of Brush Beryllium Company's QMV-200-A pressed and sintered block by anodic, chemical, and liquid honing methods.

b. Bonding the above panels with HT-424 film adhesive.

c. Lap shear testing of bonded specimens at room temperature, 500°F and 800°F.

d. Visual examinations of failed specimens.

4.0 Status and Results - The test work has been completed and the final laboratory report is being written. Of the six beryllium surface preparation methods investigated, the combined liquid honing and alkaline cleaning procedure produced the highest bond shear strength at 800°F (1254 psi) and is a very efficient reproducible manufacturing process.

1.0 Index Code . . . . (Be-Plstc-6A)(I-i)
(Be-Plstc-6, 13A)(I-i)

2.0 Title - T.R. No. 52-051.03.02, Ablation Shield Development Testing: Adhesive Evaluation and Elevated Temperature Properties.

3.0 Objective - The purpose of this phase of the ablation shield development program is to evaluate several high temperature adhesives and to determine their short time elevated temperature shear properties. The scope of this test program includes the following:

a. Surface preparation of finger panels of Brush Beryllium Company's QMV-200-A pressed and sintered block by liquid honing and alkaline cleaning.

b. Bonding the above panels with HT-424, EC 1639 plus AF 107 and Aerobond 430 adhesives.

c. Determining the lap shear strength of bonded specimens at room temperature, 500°F, 650°F and 800°F.

d. Visual examination of failed specimens.

4.0 Status and Results - The test work has been completed and the final laboratory report is being written. A tabular summary of test results obtained is presented below.

a. Shear Strength Properties (Average Results)

Adhesive	Curing Method	Failing Stress (psi) and Type of Failure at Test Temperature							
		Room Temp.		500°F		650°F		800°F	
		Stress	(7)	Stress	(7)	Stress	(7)	Stress	(7)
HT-424	(1)	3931	B	2079	C	1620	C	1264	C
	(2)	3959	B	2070	C	1646	C	1222	C
EC 1639 +	(3)	3897	C	2213	C	1416	C	898	C
AF 107	(4)	3510	C	2172	C	1364	C	824	C
Aerobond	(5)	4254	B	2247	C	1454	C	1052	C
430	(6)	4500	B	2358	C	1568	C	1048	C

Notes:

(1) 330°F for 120 minutes.

(2) 330°F for 60 minutes + 400°F for 60 minutes.

(3) EC 1639 at 325°F for 30 minutes; AF 107 at 350°F for 60 minutes.

(4) EC 1639 at 325°F for 30 minutes; AF 107 at 260°F for 90 minutes, 350°F for 60 minutes.

(5) Heat to 330°F in 20 minutes, hold at 330°F for 60 minutes.

(6) Heat to 330°F in 50 minutes, hold at 330°F for 60 minutes.

(7) Type of failure: B - Beryllium specimen failure
C - Bond failure

b. Joints produced with Aerobond 430 developed the highest shear strength at room temperature and 500°F. HT-424 adhesive joints exhibited the highest shear strength at 650°F and 800°F.

1.0 Index Code . . . . (Plstc-6HCM)(I-b, 1)

2.0 Title - T.R. No. 32A-013, Evaluation of Various Adhesives for Bonding Core to Ribs and Spar in The 32-21150-505/506 Assemblies Containing Non-Perforated Core.

3.0 Objective - To evaluate various adhesives for bonding core to ribs and spar in the 32-21150-505/506 F-4H Stabilator Trailing Edge assemblies containing nonperforated aluminum honeycomb core. The scope of this investigation includes the following:

a. Fabricate test panel #386 using two layers of FM96 supported film adhesive for bonding core to ribs and spar. FM61-BR227A adhesive system is to be used for skin to core and all metal-to-metal bonds.

b. Fabricate test panel #385 using two layers of BR-92 with hetanhydride curing agent supported epoxy paste adhesive for bonding core to ribs and spar. The BR-92B specified for this panel was not available at time of fabrication.

c. Core to rib strength at 350°F for test specimens made from panels #385 and #386.

d. Core to spar strength at 350°F for test specimens made from panels #385 and #386.

e. Transverse and longitudinal shear strength at room temperature and 350°F for test specimens made from panels #385 and #386.

f. Short column compression strength at room temperature and 350°F for test specimens made from panels #385 and #386.

g. Climbing peel strength at room temperature for test specimens made from panels #385 and #386.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. A tabulated summary of data obtained is presented below.

Type of Test	Panel #385	Panel #386	M.A.C. P.S. 14029 Requirements
Core to Rib Strength at 350°F (psi)	92.5	21.8	
Core to Spar Strength at 350°F (psi)	153.0	133.0	-
Transverse Shear at Room Temp. (psi)	277.0	310.0	205.0
Transverse Shear at 350°F (psi)	157.0	181.6	134.0
Longitudinal Shear at Room Temp. (psi)	518.0	460.0	335.0
Longitudinal Shear at 350°F (psi)	168.0	313.0	220.0
Short Column Compression Strength at Room Temp. (psi)	80,600	82,000	68,000
Short Column Compression Strength at 350°F (psi)	49,370	52,075	55,000
Climbing Peel Strength at Room Temp. (in/lb/in)	24.2	28.9	20

1.0 Index Code . . . . (Plstc-:A, 13A, 24A)(II-h)

2.0 Title - T.R. No. 32A-028.07, Determination of Water Transmission Through Cured FM-47 and FM-61 Supported Adhesive Films in Metal-To-Metal Bonds.

3.0 Objective - To determine if water will pass through cured FM-47 and FM-61 supported adhesive film in metal-to-metal bonds of aluminum honeycomb panels. The scope of this investigation includes the following:

a. Preparation of two specimens containing perforated core and FM-47 adhesive.

b. Preparation of two specimens containing nonperforated core and FM-61 adhesive.

. ·xose each test specimen to immersion in distilled water for 14 days at room temperature. Remove test specimens every 24 hours and weigh to the nearest 0.001 gram.

d. Determination of weight of each test specimen before, during and after immersion in distilled water.

4.0 Status and Results - The test work has been completed and the laboratory report is being written. Test results indicate that specimens containing FM-47 adhesive showed no evidence of distilled water being wicked into the two specimens by the glass fabric carrier of the FM-47 adhesive. Tests of the FM-61 adhesive film bonded specimens were cancelled because FM-47 adhesive exhibited no wicking action.

1.0 Index Code . . . . (Plstc-6A)(I-F)

2.0 Title - T.R. No. 32A-028.08, Investigation of Heating and Freezing Effects of Water on Honeycomb Panels.

3.0 Objective - To determine what effect various water solutions have upon the strength of FM-47 adhesive core-to-skin bonds of sandwich structure containing perforated aluminum honeycomb. The scope of this investigation includes the following:

a. Fabrication of honeycomb specimens from outer wing panel of F4H-1 aircraft as follows:

1. Cut two 6.0 inch by 6.0 inch specimens and drill 0.021 inch diameter holes in one of the skins of each specimen into ten percent of the cells. Fill the drilled cells with tap water and seal the holes. The edges of one specimen are to be sealed using Epon VIII and the edges of the other test specimen are to be unsealed.

2. Cut eighty-one honeycomb specimens (1.00" x 1.00" x thickness) with 0.021 inch diameter drilled holes in the top skin for injection of 5% NaCl, tap water, distilled water, Type "A", Type "B" solutions.

b. Subject 6.0" x 6.0" honeycomb specimen with sealed edges to the following cyclic test procedures:

1. Place specimen in a desiccator and apply a vacuum of 24 inches of Hg.

2. Raise the temperature of specimen to 180°F for one hour.

3. Lower the temperature of specimen at room temperature.

4. Subject specimen to coin-tapping and X-Ray inspection for detection of failure areas.

5. Repeat the above test procedure on the same specimen at 200°F, 250°F, 300°F and 350°F.

c. Subject the 6.0" x 6.0" specimen with unsealed edges to a temperature of 20°F for two hours. Inspect for presence of failure areas by coin-tapping and X-Ray inspection methods. Seal edges of the specimen with Epon VIII and cool specimen to 20°F for 2 hours and inspect for failures.

d. Dissection of both 6.0" x 6.0" honeycomb specimens for presence of failure areas.

e. Exposure of 1.0" x 1.0" x thickness honeycomb specimens in solutions of 5% NaCl, tap water, distilled water, solutions Type "A" and Type "B" for time intervals of 7, 14, 21, 30 and 60 days.

f. Flatwise tensile strength at room temperature of solution exposed honeycomb test specimens.

4.0 Status and Results - This test program is partially completed. A summary of test results obtained thus far is presented below.

a. Both 6.0" x 6.0" honeycomb specimens were dissected and no failures were observed.

b. Average Flatwise Tension Test Results

Exposure Solutions	7 Day Exposure (psi)	14 Day Exposure (psi)	21 Day Exposure (psi)	30 Day Exposure (psi)	Average of all 4 Groups: Failing Stress (psi)	Average of all 4 Groups: % Compare To Control Spec. No Exposure
5% NaCl	393	382	410	423	402	100.5
Tap Water	398	407	404	411	405	101.2
Distilled Water	348	406	335	350	360	90.0
*Solution "A"	400	387	N.A.	372	386	96.5
*Solution "B"	N.A.	330	N.A.	N.A.	330	82.5
Control	---	---	---	---	400	---

*NOTES: Solutions "A" and "B" were removed from honeycomb panels on airplanes which were still in the assembly stage.
N.A.: Not Applicable.

VOUGHT AERONAUTICS
A Division of Chance Vought Corporation
P. O. Box 5907 • Dallas 22, Texas

Oct 61

MAXIMUM TEMPERATURE TESTS FOR LOW MODULUS ZIRCONIA CEMENT DEVELOPMENT

PURPOSE

The purpose of this test was to determine the maximum usable temperature of various Zirconia cements.

TEST SPECIMENS

Approximately fifty specimens fabricated from different Zirconia cement compositions were used for these tests. The specimens were approximately one inch in diameter and were mounted in a Zirconia fire brick in a manner to allow the specimen to protrude one-half inch beyond the surface of the brick.

TEST PROCEDURE

The specimens were installed in a carriage mounted propane torch facility for testing. The carriage was programmed to produce a surface heating rate of 15°F/sec. to a temperature of 3000°F. Temperatures were monitored through the use of an optical pyrometer.

CONCLUSIONS

The tests produced specimen failures at temperatures as low as 3170°F when the specimen desintegrated to as high as 4680°F at which point the specimen melted. Specimens with cerium nitrate, thorium nitrate, and cobalt oxide coated surfaces survived temperatures in the 4000 to 4100°F range with no apparent damage. Emissivity values were determined for the coated specimens, and at temperatures up to 3400°F they were significantly higher than that for the uncoated surfaces.

REFERENCE

Chance Vought Test Request 61-59000-1 dated 9 January 1961.

Index No. 394

THE BOEING COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Aug 61

MATERIAL CLASSIFICATION:

CERAMIC, CERMET, OXIDE, CARBIDE, AND INTERMETALLIC; BEARING

DESCRIPTIVE TITLE:

Investigation of Refractory Materials Fricition Characteristics at Elevated Temperatures

OBJECTIVE:

To provide a basis for the selection of materials for use in plain and anti-friction bearings for high temperature service.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Seventeen sliding friction and twenty-four rolling friction tests have been conducted in air at temperatures 3000°F. Materials tested were Al_2O_3, $Al_2O_3 \cdot MgO$, BeO, SiC, ZrO+Fe, CrB_3, $Al_2O_3 \cdot 2SiO_2$, ZrO+Ag, TiC+Ni Cermet, Mo, Cb, Sn, TiB_2, $MoSi_2$, TiO_2, SiC, TaC, and CrB.

The materials which were optimum from a friction aspect under sliding conditions were CrB at 1500°F, ZrO+Ag at 2000°F, and BeO at 2500°F and 2900°F.

Al_2O_3 was the best material tested under rolling friction conditions to 2500°F. ZrO_2 was best at 3000°F, but compatability with some materials is uncertain.

Index No. 395

2-5546-0-9

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

CERAMICS; CARBIDES; STRUCTURAL

DESCRIPTIVE TITLE:

Carbide Material Development

OBJECTIVE:

To determine the feasibility of using selected carbides as structural materials.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Samples of HfC, TaC, ZrC-4TaC and 1HfC-4TaC were prepared by sintering at 4500°F and by pressure sintering at 3800°F and 3000 psi pressure. Specimens of 1HfC-4TaC and HfC were produced with 20% and 40% porosity respectively. These samples had modulus of ruptures of 4000 and 3500 psi respectively, at 3500°F. Great improvement can undoubtably be made in the strength of these materials by producing bodies with lower porosity.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

CERAMICS; BERYLLIUM OXIDE; PROPERTIES

DESCRIPTIVE TITLE:

Investigation of Beryllia

OBJECTIVE:

Determine the thermal expansion, flexural strength, emittance, modulus of elasticity, dielectric constant, and loss tangent of Coor's Beryllia (B-932) at temperatures to 2500°F.

ABSTRACT OF RESULTS AND CONCLUSIONS:

The thermal expansion to 1800°F, flexural strength to 3000°F, emittance and modulus of elasticity to 2500°F, dielectric constant and loss tangent to 1800°F were determined for Coor's Porcelain Company Beryllia Compound B-932. The results are as follows:

1. Specific Gravity: 2.87
2. Thermal Expansion: 4.620×10^{-6} in/in/°F at 1800°F
3. Flexural Strength: 17,500 PSI at room temperature with a maximum of 27,430 PSI at 1500°F and 4000 PSI and no strength at 2500°F and 3000°F respectively. A loading rate of 6000 PSI/min was used in all flexural strength tests.
4. Emissivity varied from .71 at 1100°F to .33 at 2300°F.
5. Modulus of elasticity (sonic method) varied from 47.5×10^6 psi at 72°F to 40.6×10^6 psi at 2350°F.
6. Loss tangent varied from .0026 at 72°F to .0021 at 1850°F. The tests were performed at a frequency of 9375 MCS.
7. Dielectric constant varied from 6.85 at 72°F to 7.95 at 1800°F. Test frequency - 9375 MCS.

Complete program details will be found in BAC Document D2-10503.

Index No. 397

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION: 31 Jan 61

CERAMICS; ALUMINA; REFRACTORY

DESCRIPTIVE TITLE:

Thin Dielectric Material Development

OBJECTIVE:

Develop a process for conversion of thin sheets or filaments of aluminum to alumina (Al_2O_3) by electrolytic conversion.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Thin alumina sheets in thicknesses from 0.003" to 0.012" were made by electrolytic oxidation of aluminum sheets. They consist of amorphous alumina and are transparent. Their flexural strength at R.T. is 30,000-40,000 psi; their eleastic modulus 13 to 17 x 10^6 psi. When fired the material undergoes phase changes from γ-alumina to α- alumina.

Alumina filaments of over 10' length were made by the same proprietary process using aluminum wires of AWG 36 to 44. The conversion can be carried out with militple strands of straight wires or with wires twisted or braided to obtain alumina cords or cables.

Reference - BAC Document D2-10216, "Fabrication of Refractory Oxide Thin Sheets and Filaments by Electrolytic Conversion of Metals"

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION: 31 Jan 61

CERAMICS; ZIRCONIUM OXIDE; FOAM DEVELOPMENT

DESCRIPTIVE TITLE:

Ceramic Foam Development

OBJECTIVE:

To develop zirconia base foams having densities from 40-60 lbs/cu.ft. and usable on the hot face to temperatures in excess of 4000°F.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Techniques for producing low temperature curing acid bonded and sintered zirconia foams have been developed.

Densities from 27-90 lbs./cu.ft. have been produced by acid bonding and as low as 19 lbs./cu.ft. by a whipped water and sintering technique.

Utilizing the acid-bonded, foamed-in-place, zirconia to fill super alloy honeycomb, heat-shield panels were produced which were usable at temperatures in excess of 3000°F and which had a density-coefficient of thermal conductivity product below $15 \frac{\text{BTU-lb}}{\text{Ft}^4\text{-°F-hr}}$

Thermal drops of 1750°F have been measured through a 1" thickness of the sintered 40 lb/cu.ft. foam exposed to a hot face temperature of 3000°F. This material has a coefficient of thermal conductivity of $2.5 \frac{\text{BTU-in.}}{\text{Ft}^2\text{-hr-°F}}$ at a mean temperature of 2000°F. It melts at a temperature above 4000°F.

Reference - D2-10339, Foam Ceramic Development

Index No. 399

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION: 31 Jan 61

CERAMICS; GRAPHITE; LEADING EDGE

DESCRIPTIVE TITLE:

Composite Leading Edge Material Development and Evaluation

OBJECTIVE:

To develop, fabricate and evaluate composite ceramic leading edge materials.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Graphitic base materials possessing excellent oxidation resistance to temperatures near 3000°F have been developed and are being considered for leading edge usage.

Dry pressing, hydrostatic pressing, brushing and trowelling techniques are being investigated for fabrication of the leading edge.

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

MATERIAL CLASSIFICATION: 31 Jan 61

CERAMICS; GRAPHITE; DEVELOPMENT

DESCRIPTIVE TITLE:

Graphite Materials Development

OBJECTIVE:

To develop graphite base materials usable to temperatures above 3000°F in oxidizing atmospheres and possessing mechanical properties superior to pure graphites.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Graphitic base materials have been developed which have the inherent property of developing a protective oxide coating when exposed to high temperature oxidizing environments. The materials are usable in oxidising environments for extended times at temperatures around 2600°F and for shorter times at temperatures near 3000°F.

Strengths of the materials at both room temperature and 3000°F are higher than those obtained from commercial graphites. Room temperature flexural strengths at 9,000 to 10,000 psi have been obtained. Compressive strengths at room temperature range from 16,000 to 20,000 psi. The density of the materials is about 2.50 g/cc.

This work will be reported in document D2-9479, "Oxidation Resistant Graphite Bodies".

BOEING AIRPLANE COMPANY

MATERIALS PROGRAM ABSTRACTS

31 Jan 61

MATERIAL CLASSIFICATION:

CERAMICS; CHEMICALLY BONDED CHROMIA-ALUMINA; LEADING EDGE DEVELOPMENT

DESCRIPTIVE TITLE:

Composite Leading Edge Material Development and Evaluation - Dyna Soar

OBJECTIVE:

To develop, fabricate and evaluate metal-ceramic composite leading edge materials.

ABSTRACT OF RESULTS AND CONCLUSIONS:

Preliminary test data has shown that the composite system of chemically bonded chromia-alumina reinforced with AM-350 honeycomb is extremely promising for leading edge applications.

Costly and complicated heating equipment is not necessary for fabrication since the composite is immediately suitable for elevated temperature usage after being cured to only 800°F.

Scale model curved leading edge specimens of the aforementioned composite readily withstood oxygen acetylene torch heating for 15 minutes at 2500°F.

Work is in progress to prepare suitable test specimens to enable the measurement of physical properties.